Educational Interventions in Biology: Improving Children's Understanding of Illness

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Declaration

I declare that this thesis was composed by me and that I carried out the work presented here, except where indicated in the text. It has not been submitted in part, or in whole, for any other degree.

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Abstract

Cognitive development is widely believed to occur in a domain-specific fashion (Chomsky, 1975; Fodor, 1983, Hirschfeld & Gelman, 1994) and it has been suggested that children have three core domains of thought: physics, psychology and biology (e.g. Carey, 1985; Wellman & Gelman, 1992). However, there is disagreement among researchers surrounding when and how biological understanding arises. This thesis reports three studies about children's understanding of illness, an important area of biological knowledge. The first aim of this thesis is to examine the development of children's understanding of illness within the context of the debates on biological knowledge.

Further, it has been identified that children's conceptions of illness often differ from the ones being taught (Au & Romo, 1999) and can act as barriers to learning (Driver, Guesne & Tiberghien, 1985). Therefore, there is a challenge to develop effective intervention methods to improve understanding in this area; this is the second aim of this thesis.

Study 1 reports the findings from an investigation into children's understanding of a range of illnesses. It was found that children's understanding of different illness becomes more sophisticated and accurate with age. Specifically, children employed a physical model (e.g., He caught a cold because it was cold) to conceptualise illness and gradually moved to a biological model with age, in line with the suggestions of Au and Romo (1999) and Kalish (1999). They also appeared to explain injuries purely in a physical way, and these explanations became more detailed and accurate with age. A further finding is that children seem to have different levels of knowledge for different illnesses.

The results of Study 1 also provided a baseline measure for the subsequent 2 studies, by identifying that children's understanding of contagious illness as a good candidate for intervention. Study 2 compared three different intervention conditions for improving knowledge of the common cold and chicken pox. These were a group

condition plus factual information, a group condition, and an individual condition plus factual information. Measures of two non-contagious illnesses were also taken at pre- and post-test. Only one significant difference was found: the group plus facts condition had higher pre- to post test change scores for cold than the group condition. However, trends in the data indicated that the conditions in which factual information was provided were more successful than those that did not. As well as differences between the intervention conditions, the older age group showed greater pre- to post-test improvement than the younger age group. Additionally, improvements in knowledge did not generalise to non-contagious illnesses.

Study 3 built on the findings of Study 2 by further investigating factual information as the chosen intervention method. In this study, factual information was teamed with an individual activity and the comparisons were made between different types of factual information. It was found that factual information that included detailed explanations of biological functions lead to greater improvements in knowledge than factual information that only gave basic facts. Certain age dependent trends first seen in Study 2, were also seen in Study 3: notably, the 11 year old age group showed greater improvement than the 7 year olds. Furthermore, the increased understanding of contagion generalised to other contagious illnesses and not just the target illnesses of cold and chicken pox.

The findings from the studies lead to the conclusion that children develop a biological understanding of illness at around 7-9 years, before which they understand illness in physical terms. This corresponds with the theoretical positions of Kalish (1999) and Au and Romo (1999). Intervention methods that were best placed to improve children's understanding of illness were those that were successful in promoting engagement with the task. The provision of explanations of illness processes was particularly successful. The findings of this thesis not only further the knowledge on the structure and development of children's biological knowledge, but they also contribute to debate on the best way to teach about biology and health.

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Chapter 1:

Theories of Cognitive Development and Children's Understanding of Biology

1.1. Aims of this Thesis

Research has identified that children have intuitive scientific knowledge before being taught it in school (Wellman & Gelman, 1992). These naïve conceptions often differ from ones that teachers are trying to teach and can act as barriers to learning (Driver, Guesne & Tiberghien, 1985). Intervention methods which engage children's intuitive knowledge have been shown to improve understanding of physics (Howe, Rodgers & Tolmie, 1990) and recent research has suggested that similar intervention methods may be successful in improving understanding of biology, including concepts of illness and health (Sigelman et al., 1996; Solomon & Johnson, 2000). There is a lack of research in this area, however, which this thesis will help to redress.

This thesis will focus on children's understanding of illness, an important area of biological knowledge (Siegal & Peterson, 1999). The aims are twofold. Firstly, the thesis aims to provide a comprehensive picture of the development of children's illness concepts throughout childhood and identify gaps in their knowledge that may benefit from intervention. The second aim is to develop intervention methods that may be successful in improving children's understanding of illness by specifically targeting the identified gaps in conceptual understanding. The results will add to knowledge on how children conceptualise illness and the different instruction methods that are successful in teaching about this concept. This is especially pertinent regarding recent theories of domain-specific development as there is current debate regarding the presence of a domain of biology, separate from other areas of understanding, the age at which this domain emerges and the processes that influence development within this domain. In addition, this thesis will have strong practical implications regarding teaching health and illness concepts in schools and communicating about illness in health care settings.

To fulfil these aims, three empirical studies will be conducted. These are reported in Chapters 4, 5 and 6. Chapter 4 reports a study that will meet the first aim by interviewing children about a variety of illnesses and illness processes. The research to be reported in Chapters 5 and 6 will compare different intervention types for improving children's understanding of illness, thus satisfying the second aim of this thesis.

1.2. Introduction

This chapter will begin by describing theories of development. Traditionally, educational practice has been influenced by theories within psychology, therefore this chapter provides a basis for the rest of the thesis. Firstly, Piaget's theory of development will be outlined. His account of development proposes that development proceeds simultaneously across all domains of knowledge as a result of changes in cognition. This chapter will show how discontentment with these ideas led to the recent school of thought that proposes domain-specific development. Domain-specific theorists argue that several foundational areas of understanding develop independently from one another and children's abilities in one of these areas does not always reflect their abilities in another. Within this school of thought, however, there are several contrasting accounts in the way in which cognition is organised. This chapter will cover modular accounts of development as well as intuitive theory perspectives.

The second part of this chapter will discuss the literature covering children's biological knowledge. Again, there are several conflicting ideas about how children understand biological phenomena which will be covered in this chapter. The chapter will conclude with implications for the rest of the thesis as these discussions provide the grounds for the next two chapters that discuss children's concepts of illness and different intervention methods. Accounts of children's conceptual development have been heavily influenced by theories of development as will be shown in Chapter 2. Furthermore, theories of development have implications for teaching and instruction methods to be discussed in Chapter 3.

1.3. Piaget's Domain-general Theory of Development

The first, and most comprehensive, theory to date of development is that of Piaget (Piaget & Inhelder, 1969). Piaget believed that knowledge is constructed. He did not see it as innate as proposed by Chomsky (1986), nor as a sole product of the environment as argued by Skinner (1957). Instead Piaget thought development was a result of the interaction between the individual and the environment. This interaction was not just described as the individual acting upon the environment but also the environment acting upon the individual. Mental development was characterised by major qualitative changes which occurred through a process of assimilation and accommodation. Assimilation being the process of taking in new information and transforming it to fit in with previous ways of thinking. Accommodation being when existing mental structures are adapted to incorporate incoming information.

Piaget and Inhelder (1969) proposed that development proceeds through a series of stages, each qualitatively different from one another. At each stage the child makes use of different internal mechanisms for organising information, and at each new stage, capacities developed at an earlier stage are reworked into a more complex structure. Children pass through the stages at different rates, but the stages are always passed through in a fixed order. The four main stages of intellectual growth are: the sensori-motor period, the pre-operational period, the concrete operational period and the formal operational period. From birth to approximately 18 months is classified as the sensori-motor period, where the infant explores and recognises objects with the senses. The pre-operational period is between 18 months and 7 years and children begin to represent actions with symbols but their thinking is still linked to their own perceptions. During the concrete operational period, 7 years to 12 years, children become capable of logical thought and begin to grasp abstract notions such as conservation of liquids and substance. However, children at this stage still have problems with abstract thought which does not become possible until the formal operational period. At this stage, children are able to understand highly abstract and formal relationships.

Domain-general theories of development were accepted for a long time as accurately characterising children's mental development and as such have had strong implications for educational practice. The idea that children's thinking is qualitatively different from adults has made cognitive development more than a matter of merely giving children more information to increase their level of knowledge. In particular, Piaget saw the child as an active learner, who needs to construct knowledge. One example of this in practice is in mathematics and science lessons, where children can be helped to make the transition from pre-operational thinking to concrete operations through encouraging practical and experimental work. Piaget emphasised individualised learning approaches but also acknowledged the importance of social interaction as a factor in cognitive development. He proposed that by listening to other children's viewpoints and having their own views challenged, cognition would advance through a process of cognitive conflict. This idea will be explored in more depth in Chapter 3 when discussing different methods of instruction for use in learning environments.

1.3.1. Criticisms and Alternatives to Piaget's Theory

Despite its huge influence, Piaget's theory has come under serious criticism. Vygotsky (1978) argued that Piaget's theory neglected the effects of the social environment. In contrast, sociocultural factors are the main emphasis of Vygotsky's theory. Like Piaget, he acknowledged that biological and environmental factors interact to produce development, but instead of focusing on internal, mental structures, he said that the biological and environmental factors may have very different effects depending on the people among who the child grows up in, i.e. the culture of the people. The most important concept to come out of Vygotsky's theory is the zone of proximal development (ZPD). Chapter 3 includes further discussion on Vygotsky's theory.

Other criticisms of Piaget are a result of subsequent research, which has demonstrated that young children's abilities are greater than suggested. Firstly, Donaldson (1978) led a research effort to show that failure on classic Piagetian tasks did not indicate lack of cognition. Instead, it was argued that the demands of the task were too high or didn't make "human sense". More recently, new methodological techniques for studying infancy have been developed and research on innate cognitive capabilities indicates that children have greater abilities in infancy than domain-general theorists would suggest. For example, using a preferential looking task, it has been shown that infants show surprise (by looking longer) at a ball that stops in mid-air without support, indicating they are sensitive to violations of certain laws of physics (Spelke, Breinlinger, Macomber & Jacobson, 1992). As well as providing evidence for greater abilities in infancy, findings such as this are consistent with theories of domain-specific development. In this example, children are shown to have a knowledge of physics that is specialised. If development were domain-general, then children would also be expected to display a level of understanding of other concepts commensurate with their physics understanding. However, this is not the case.

There is a large body of evidence that suggests many conceptual abilities are specialised for particular types of content. To take one example, memory skills have been shown to be affected by specific content. This was demonstrated empirically by Chi (1978) who found that children who were chess experts massively outperformed adult chess novices on memory for chessboard positions. However, the adults scored higher in standard memory tasks indicating a developmental advantage. Results such as these imply that memory does not develop in a domain-general fashion, but is tied to different contents. Additionally, a strand of research on atypical populations also suggests domain-specific development. For example, Baron-Cohen (1997) found that children with autism performed worse than a normal population in tests of psychology but similar deficits were not found in their understanding of physics.

1.4. Domain-specific Theories of Development

In response to these strong criticisms of domain-general theories, the view that cognition may differ in different areas or domains of knowledge has become more established (Chomsky, 1975; Fodor, 1983; Hirschfeld & Gelman, 1994). This view has arisen both as a result of discontentment with the domain-general accounts and also newer research which suggests that many conceptual abilities seem specialised for particular types of content (e.g. Chi, 1978; Gelman & Baillargeon, 1983) However, there is not agreement on a complete theory of domain-specific development. The general claim is that the mind is "modularised" and conceptual understanding of one sort is likely to be quite different in character, structure and development from understanding of another sort (Fodor, 1983). However, different theorists disagree on what such domains of knowledge constitute, whether or not understanding within these domains is theoretical and whether they are innate or a product of development. First, modular accounts of development include Fodor's (1983) account of innate modules and Karmiloff-Smith's (1992) theory of the development of modularity. Secondly, there is the idea that children construct intuitive theories about the world, as proposed by Wellman and Gelman (1992), Carey (1985) and Gopnik and Meltzoff (1997).

1.4.1 Modular Accounts Of Development

Fodor's 1983 book "*The Modularity of Mind*" made a significant impact on theories of cognitive development by suggesting that the human mind was made up of genetically specified, independently functioning, special purpose "modules" or input systems. This was in stark contrast to the previous domain-general theories. Fodor's model of the mind has three major components: transducers, input systems, and central systems. Transducers process sensory information about the outer world and translate this information into a format for the perceptual system. Input systems process the information and deliver representations of the world to the central processor. These input systems (or modules) are the key part of Fodor's theory of modularity of mind. They are domain-specific and work independently of other modules. The essential characteristic of these modules is their informational encapsulation. The central processor is concerned with higher cognitive functions (e.g. planning, problem solving) and is domain-general. It builds a belief system from outputs of modules and long term memory.

Despite the major influence that Fodor's ideas have had, they have come under vigorous criticism, most notably from Karmiloff-Smith (1992). She acknowledges the strengths of modularity but questions whether such modules are innately pre-prescribed. This leads her to take a more developmental perspective where she replaces the view of pre-specified modules in favour of a process of 'modularization' that occurs via development. By this view, innate domain-specific constraints are acted upon by domain-general processes. This allows for a more creative and flexible cognitive system. In providing research evidence for her theory, Karmiloff-Smith investigated the domains of language, physics, mathematics, psychology and notation.

The domain-general process of development she proposes is called Representational Redescription (RR). Within each domain, the process of RR is the same, but it is affected by the form and the level of explicitness of the representations supporting particular domain-specific knowledge at a particular time. Karmiloff-Smith describes the RR model as a phase model as opposed to a stage model. By this view, representational redescription is not age-related and can occur recurrently within domains throughout development. There are three phases involved in development. During Phase 1 the child focuses on external data in any microdomain to create “representational adjunctions” (Karmiloff-Smith, 1992, p.18) which are added domain-specifically. In Phase 2 system-internal dynamics take over such that internal representations become the focus of change. Finally, in Phase 3, internal representations and external data are reconciled and a balance achieved between quests for internal and external control. Additionally, the RR model has four levels at which knowledge is represented and re-represented. These are: Implicit, Explicit-1, Explicit-2, and Explicit-3. The general idea is that children’s implicit non-verbalised knowledge (i.e. I level representations) are gradually restructured into E1 level representations. These differ from the I level representations as they are more flexible and manipulable. However, they are not available to conscious access or report. Further redescription leads to E2 level representations that are open to conscious access and finally E3 level representations that are both entirely open to conscious access and explicit verbalisation. Karmiloff-Smith stresses the importance of verbal interaction with others here as she believes it is possible that some knowledge learned directly in linguistic form is immediately stored at level E3.

1.4.2 Theory-Based Accounts of Development

By contrast to modular approaches, many researchers assert that young children's knowledge is 'theory-like' and suggest that conceptual development involves intuitive theory construction and reformulation. Wellman and Gelman (1992) suggest that children begin to understand the world through framework theories (see also Inagaki & Wellman, 1997; Wellman, 1990). They suggest that there are three core framework theories that children appeal to before developing detailed understanding of a particular topic: physics, psychology and biology. These areas of understanding encompass most of the external world with which we interact and are frequently argued to possess an evolutionary advantage (Pinker, 1997). This makes intuitive sense as an understanding of physics allows you to survive in the physical world i.e. if we had no notion of gravity, we would be less concerned about the consequences of walking over the edge of a cliff. An understanding of psychology allows us to attend to other human beings, distinguish between humans and other entities and as we get older, understand different intentions and beliefs. Finally, an understanding of biology helps us understand which animals are dangerous, which are food, how to look after our own bodies and keep ourselves healthy.

Wellman and Gelman (1992) further distinguish between framework theories and specific theories. Framework theories represent the most general explanatory notions and basic causal devices about a set of phenomena that a person uses. Specific theories focus on causal reasoning within a domain and are more detailed than framework theories. Above all, framework theories are regarded as acting as an umbrella for understanding specifics:

> ...framework theories outline the ontology and the basic causal devices for their specific theories, thereby defining a coherent form of reasoning about a particular set of phenomena. (Wellman & Gelman, 1992, p.341).

Carey (1995) also argues that a set of framework theories (or 'intuitive' theories) guide children's reasoning about the world. She specifically proposes that there are innate domain-specific systems of knowledge for physics, number and psychology. As we shall see later in this chapter, Carey differs from Wellman and Gelman in that she does not consider biology to be an innate domain of knowledge. Carey defines a framework theory as a cognitive structure that guides perception and reasoning within a particular domain of knowledge and is organised around a body of core principles. These innate framework theories form the basis for development and Carey suggests this development occurs through a process of conceptual change. This provides an alternative process of domain-specific development to Karmiloff-Smith's process of RR. Instead of knowledge becoming more explicit, conceptual change is described as the reorganisation and restructuring of knowledge. By this view of development, there is a radical overhaul of initial conceptions within a domain which means that understanding held by older children and adults is qualitatively different from young children. Carey (1985) distinguishes between two different types of restructuring. Firstly, there is the novice–expert shift as depicted by Chi, Glaser and Rees (1982). Carey (1985) describes this as “weak” restructuring where the later conceptual system represents different relations between concepts than the earlier one. Alternatively, “strong” restructuring is likened to theory change in science. This includes changes in the individual core concept and is described as conceptual change in its true sense. Carey (1985) stresses that the analysis of conceptual change is extremely difficult and it is not always obvious what sort of restructuring has taken place in the development of concepts.

In a similar vein, proponents of the 'theory theory' also argue that conceptual development is characterised by theory formation and change (Gopnik & Wellman, 1994; Gopnik & Meltzoff, 1997). However, Gopnik and Meltzoff (1997) place a stronger emphasis than Carey (1985) on children's "starting-state" (p.51) and believe that children have innate theories that are later modified and revised. Despite advocating the presence of innate knowledge, they do not believe, like Fodor (1983), that knowledge is modularised. The main difference between modularity and the 'theory theory' is the process of development. While Fodor would say that modules are genetically predispositioned to develop and therefore any experience and evidence encountered by the child is not important, Gopnik and Meltzoff (1997) place great importance on input (see also Gopnik, 2003).

The basic idea is that children have intuitive theories of the world, analogous to scientific theories and that the way these theories develop is similar to scientific theory change (Gopnik et al., 2004). Children's theories are abstract, coherent, systems of entities and rules that enable children to make predictions about new evidence, to interpret evidence, and to explain evidence. Conceptual development is characterised by theory change that occurs when the child comes across evidence that cannot be properly explained by the present theory. Children actively experiment with and explore the world, testing the predictions of the theory and gathering relevant evidence. Some counter-evidence to the theory is simply reinterpreted in terms of the theory but when many predictions of the theory are falsified, the child begins to seek alternative theories. If the alternative does a better job of predicting and explaining the evidence, it eventually replaces the existing theory. In line with Wellman and Gelman's (1992) account, the core domains of knowledge that this theory believe are present are physics, psychology and kinds (Gopnik & Meltzoff, 1997;Gopnik, 2003).

1.4.3. Criticisms of Domain-specific Theories

As previously mentioned in this chapter, the two main domain-general theories have had a significant impact on educational practices throughout the past century. However, the domain-specific account is yet to strongly influence practitioners and many practices based on domain-general theories are still observed in classrooms today. This must be partly due to the lack of consensus within the domain-specific school of thought on a range of issues. This has lead to a variety of contrasting theories which have a lot in common but disagree on key issues. Due to these controversies, no consistent implications can be teased out from the research. For example, there remains confusion as to what "domains" are. To some, a domain (or module) refers to highly localised area of expertise such as knowledge of chess, while to others a domain is a more widely encompassing structure such as those of physical, biological and psychological knowledge. This is not just a matter of arguing over a definition, however, it has implications for the number of domains that are said to exist. In the former case there could be thousands and in the latter very few. There are also implications for the level of generalisation of understanding that might be expected within a domain. Furthermore, there is no clear agreement on the domain-specific processes of cognitive development (e.g. RR, theory building, learning constraints). The potential usefulness of domain-specific development theories for education is indicated by one avenue of research that has identified that children have intuitive knowledge of some areas of science which has influenced teaching. This is something that will be explored further by Chapter 3.

1.5. Children's Naïve Understanding of Biology

The study of children's biological understanding was initiated by Piaget (1929) who demonstrated how qualitatively different young children's thought is from adults. Since then, a wealth of research has arisen on children's biological thought and it has been a central tenet of major theories of development. For example, as already discussed, Wellman and Gelman (1992) consider naïve biology as a core domain of thought. In the past, research has mainly focused on children's understanding of physics (e.g. Baillargeon, 1993) and psychology (e.g. Slaughter & Gopnik, 1996). It is now the case that these domains of knowledge are relatively well-understood but controversy still rages about the ways in which children understand biology (Inagaki & Hatano, 2002). Therefore, it is likely that the study of children's biological thought can provide us with a fresh perspective on our attempts to understand the world. However, as well as contributing to major theories of cognitive development, the study of biological thought is important in its own right. Theories of domain-specific development propose that different types of knowledge may be learned about in different ways (Keil & Silberstein, 1996). Therefore, it is of practical importance to determine the nature of children's biological thought to inform science education. In particular, if children come to school with some form of naïve biology, then this will hold implications for the way it is introduced into the school curriculum.

1.5.1. What Is Biological Knowledge?

Biological knowledge generally refers to the cognitive processes by which people understand, classify, reason about and explain the world of plants and animals. A naïve biology is often considered to be more than a collection of facts. Many theorists argue for a theory of biology which can provide predictions about and explain biological phenomena as growth, digestion, illness and death (Hatano & Inagaki, 1994). A naïve theory of biology encompasses a large body of knowledge. Keil (1994) set out a comprehensive list of characteristics. Firstly, category systems that are used to divide up the biological world. Not only does this encompass distinguishing between living and non-living things, but also between different types of animals, plants etc. Secondly, children's categories of living things may be structured differently from other concepts as they appear to believe that living kinds have an essence. Thirdly, biological knowledge encompasses processes such as illness, reproduction and growth. This section will include examples of each of these areas of understanding and give brief descriptions of the research and findings for each one.

To begin, a crucial component of any biological understanding is the ability to differentiate living from non-living things (Coley, Solomon & Shafto, 2002). Research with young children has previously reported that children believe that inanimate objects are alive, known as animism. This is clearly qualitatively different from an adult view. Piaget (1929) asked children if a range of inanimate objects were alive and found that children frequently said that they were (see also Laurendeau & Pinard, 1962). However, more recent evidence suggests that early studies may have overestimated children's animistic reasoning. For example, Hatano, Siegler, Richards, Inagaki, Stavy & Wax

(1993) looked at children's biological understanding in a range of different cultures. The results indicated that children in all three countries knew that people, animals, plants and inanimate objects were different types of things with different properties. As will be discussed later, cross-cultural investigation of taxonomies has been used as evidence that biological understanding is innate (Atran, 1999; Bailenson, Shum, Atran, Medin & Coley, 2002). Not only do very young children show awareness of differences between, say, the biological and physical world, but the way in which they categorise the biological world is consistent across very different cultures.

Secondly, having established that children can distinguish between animate and inanimate objects, it needs to be determined how they distinguish between different plant and animal categories. Children's categories of living things may be structured differently from other concepts as they appear to believe that living kinds have an essence (Gelman, 2004). Essentialism asserts that people act as if there is an underlying property that causes the observable characteristics of any item. It is this property, not other observable characteristics that determines category membership. One consequence of essentialist beliefs is that superficial transformation should not change the identity of a living thing. For example, children believe that a racoon painted black with a white stripe and a pouch of smelly stuff, remains a racoon despite its similarities with a skunk (Keil, 1989). Gelman and Wellman (1991) show that that when animals were reported to have their "insides" or "outsides" removed, 4 and 5 year olds treated removal of the insides as disastrous to the animal's identity but removal of the outsides was not. As a consequence of such findings, Gelman and Hirschfeld (1999) assert that "essentialism is an essential part of biological understanding" (p.438).

Thirdly, understanding of biological causal processes has been investigated. The findings from this body of research have been of importance to debate on the onset of biological knowledge. To have an understanding of a biological causal mechanism provides different evidence than, for example, identifying whether children can distinguish between living and non-living objects. It involves understanding and causally relating different concepts and is therefore a more explanatory type of knowledge. More importantly, it is possible to investigate further development of understanding of processes beyond when this knowledge emerges, making research evidence on such processes very valuable to debates on the development of biological knowledge.

The first of these processes discussed in this section is growth. Inagaki and Hatano (1996) report that four and five year olds believe that animals and plants, but not non-living objects grow over time. Furthermore, Backsheider, Shatz & Gelman (1993) report that 4 year olds realised that both plants and animals can regrow but that artefacts must be fixed by human intervention. Demonstrating that evidence from research on biological processes can be used to show more than just the existence of a domain of biology, Zhu and Fang (2000) found that 4 year olds had some understanding of growth, 5 year olds had a better understanding but this depended on the type of task used and finally, 6 year olds' performance was not so much affected by task-type and they showed a more sophisticated understanding of growth.

There is a large body of research on children's understanding of inheritance (e.g. Solomon, 2002; Springer, 1999; Weissman & Kalish, 1999; Williams & Smith, in press). Research has shown that pre-school children have knowledge of facts relating to inheritance (Gelman & Wellman, 1991; Inagaki & Hatano, 1993). However, others have argued that knowledge of these facts does not necessarily imply that these children have a theoretical understanding of biological inheritance. Solomon, Johnson, Zaitchik and Carey (1996) suggested that most pre-schoolers do not understand biological inheritance and do not have an understanding of the causal mechanisms of inheritance. In general, however, the research suggests that preschool children have a basis of understanding of inheritance and that this develops with age. Contrasts between studies emerge as a result of the different tasks used to estimate children's knowledge.

The final process to be discussed is illness which has been chosen as the topic of investigation in this thesis. Early research on illness concepts argued that they developed in line with Piaget's stages of development (Bibace & Walsh, 1981; Perrin & Gerrity, 1981) and recently they have been used to provide key evidence regarding the onset and development of children's biological knowledge (Kalish, 1997; Siegal & Peterson, 1999; Springer & Ruckel, 1992). Therefore, studying children's illness concepts can inform broader theories of development. Most important to this thesis is how children's understanding of illness can benefit broader debates regarding biology. A biological understanding of illness consists of a conceptualisation of the mechanism of contagion and the ability to reason about germs as a causal agent. Therefore, there is potential for the study of when this understanding emerges and how it develops through later childhood. Additionally, there is scope to investigate different influences on children's understanding of illness (to be discussed in Chapter 3). This has shown the theoretical benefit of researching illness concepts and Chapter 2 will further outline the practical benefits of researching illness concepts.

In sum, a biological understanding covers a wide area of knowledge. As shown by this discussion, there is debate concerning the age at which children possess a naïve theory of biology and the origins of biological thought. In particular, different areas of biological understanding and the different methodologies used exacerbate this debate. These key debates will form an important part of this thesis.

1.6. Theories of Development of Biological Understanding

Discussion of theories of domain-specificity have shown that some authors consider development to be characterised by modules or intuitive theories and this debate is mirrored in theories of biological understanding. From the literature, several conflicting viewpoints about the nature of children's biological understanding have been identified. Firstly, biology is an innate core module and it is not theory-like (Atran, 1990; Sperber, 1994). Secondly, biology is an innate core module that is theory-like (Keil, 1992). Finally, biology is an intuitive theory that is constructed during childhood and may arise from an intuitive theory of psychology (Carey, 1985) or mechanics (Au & Romo, 1999).

1.6.1. Biology as an Innate Core Domain that is not a Theory

Atran (1990) and Sperber (1994) argue that biology is a core domain of thought that is innately determined, triggered by privileged input and emerges without the aid of theory building. Within this core domain there are core modules, an example of which is a universal taxonomy (Atran, 1998). Core modules share much with Fodor's input modules but there are also differences. Input modules are closed cognitive structures that have exclusive access to their own mental representations. Core modules, on the other hand, make use of other module's inputs and outputs. This flexibility means that humans can quickly acquire different sorts of knowledge.

The evidence that is offered to support biology as a core domain of thought is based, firstly, on the evolutionary plausability argument for innate understanding of biology, and secondly on research which suggests cross-cultural universality in taxonomic organisation of categories of animals and plants. The evolutionary advantage of having an innate bias to understand biology has already been mentioned in this chapter. Atran (1998) has shown that different cultures divide the living world into two kingdoms (animals and plants), and that each of these is sub-divided into major life forms (e.g. fish, bird, mammal). Atran (1999) explains that ranking folkbiological taxonomies in this way provides a general inferential framework for category-based inductions. This allows people to readily predict and project the likely distribution of familiar or unfamiliar biologically related properties across living kinds.

However, although Atran's arguments appear plausible, his theory lacks a consideration of other aspects of biology. For example, he says nothing of whether children can reason about biology or provide explanations of biologically causal mechanisms. Not only has this been argued to be an important aspect of biological knowledge (Coley et al., 2002) but there is also strong evidence to suggest that children's understanding of biology is theoretical (discussed in the following two sections). Additionally, the main evidence in support of his theory is that there is cross-cultural universality in understanding biology. However, there are clear signs of cross-cultural variation in explanations of biological phenomena, indicating that innate mechanisms are unlikely to be operating at the level of causation (Raman & Gelman, 2004, discussed in the following chapter). Furthermore, there is no mention of how children's knowledge develops beyond their innate capabilities. This is a criticism that extends to modular theory in general. As identified by Karmiloff-Smith (1992), it is most unlikely that the experiences of children have no effect on their understanding of phenomena.

1.6.2. Biology as an Innate Core Domain that is an Intuitive Theory

Keil (1992; 1994) proposes that biology is an autonomous domain of knowledge that is construed differently from the start. However, his theory differs from the Atran/Sperber position in that children's biological understanding is theory-like. Children are predisposed to think differently and endowed with "modes of construal" that are specific for understanding the biological world. For evidence, Keil (1999) cites the study of biological concepts such as growth, illness, inheritance and reproduction as showing that pre-schoolers appear to have cores of explanatory beliefs for these biological concepts and therefore display a certain bias to explain them in a biological way. However, this cannot be called a fully conscious theory of biology at this age as they do not give specific biological mechanisms (Keil, Levin, Gutheil & Richman, 1999).

Therefore, Simons and Keil (1995) propose that children have a set of abstract principles relating to biology and these are useful in building up an understanding of specific biological mechanisms.

Keil (1989) provides evidence that children have a basic theory of biology. This study found that pre-schoolers judged that a racoon might be turned into a skunk if something internal to the skunk was changed. However, if only surface transformations took place then the animal would stay the same. However, other researchers have argued that such findings indicate that children do not have an innate theory of biology. One such theorist is Carey (1985) who cites such findings as evidence for an emergence of biology from psychology. This idea that biology is an intuitive theory that arises from another intuitive theory is covered in the following section.

1.6.3. Biology as an Intuitive Theory that is Constructed During Childhood

Both the Sperber/Atran position and the Keil position is that children's biological understanding is innate. However, there is a third possibility that biology emerges as a theory at some point during later childhood. Within this viewpoint, there are several contrasting opinions about when and how biology arises.

Carey (1985; 1995) argues that biology emerges from a first-order cognitive module of psychology. In her 1985 book, *Conceptual change in childhood*, Carey put forward an argument that children have a tendency to explain biological phenomena such as life, death and illness in terms of psychological, that is intentional, processes. For example, children might say that someone was getting fatter because they wanted to. In addition, children begin to understand animals by using the "comparison to people" model and project properties that they know humans possess onto other animals (Carey, 1985; Inagaki and Sugiyama, 1988). Carey suggested that this reliance on intuitive psychology develops into a distinct domain of biology at about the age 10 years through a process of conceptual restructuring/change.

However, these claims have been the subject of much criticism (e.g. Atran, 1994; Inagaki & Hatano, 1993; Keil, 1994; Wellman & Gelman, 1992) and there is evidence against this view. In terms of intentional causality, Inagaki and Hatano (1993) have produced a series of studies that show that children do not believe bodily processes, such as weight gain and sleep, are under a person's intentional control. In addition, it has been shown that children have some degree of knowledge of biological causation. For example, when asked which of a pair of twins would get fat, one who wanted to become fat but did not eat very much or one who wanted to stay thin but ate a lot, pre-schoolers judged the twin who ate a lot would be more likely to become fat. Results such as these have led to a revision of Carey's original (1985) position.

Carey (1995) later acknowledged that her claim that children explain all properties of animals in terms of intentional causality may be wrong. However, she also asserted that although the evidence against this claim is strong, it does not imply that there is a specific explanatory system for biology. Inagaki and Hatano's (1993) findings show that children know that there are bodily functions outside of the control of human intentional causation but they do not show knowledge of biological causal mechanisms.

Carey (1995) suggests that this only shows knowledge of input-output relations which is also the case for children's understanding of inheritance and illness. Additionally, Carey (1995) sticks by her second strand of evidence which states that children understand animals by comparing them to humans. Therefore, Carey's (1995) new proposal of the emergence of biological thought lowered the age at which she saw an autonomous biology emerging at 6 - 7 years but she still argued that it emerged from an intuitive psychology.

This view was more in line with other theorists such as Inagaki and Hatano (2002) who also argue that age 7 years is when biology emerges. However, later work by Johnson and Carey (1998) forced a further revision and the latest theory is back at Carey's (1985) position. A thorough investigation of a large number of biological concepts showed that children of age 10 years did not have satisfactory understanding of folkbiological concepts, such as life and death:

> To our surprise, the older controls had not completed the construction of T2, despite an average chronological age of nearly 10 and a mental age of nearly 11. This result is consistent with the claim of Carey (1985) that the construction of the framework theory of living kinds is a long and slow process and is not completed until the end of the first decade of life. It is inconsistent with much of the recent work pushing the age of acquisition of the living kind ontology younger, even into the preschool years. (p.194)

One of the most damning criticisms of Carey's assertions is that studies frequently find that children make no reference to psychological influences when trying to explain biological phenomena (Keil, 1992). However, it cannot be claimed that the research evidence against the emergence of biology from psychology is conclusive about the presence of an autonomous theory of biology in young children. Most of the research that argues for an autonomous theory of biology has been on input-output relations, e.g. will the character get ill or not get ill (Kalish, 1996a; Solomon & Cassimatis, 1999). Of the studies that have considered causal mechanisms for biological phenomena, some show that mechanical causality is the mechanism of choice for children (Inagaki & Hatano, 1993; Springer & Keil, 1991). Au and Romo (1999) argue that an understanding of biological causal mechanisms is not something that children can pick up in everyday life and it may require formal instruction for children to move from a mechanical understanding of biological phenomena to a biological understanding. Most of the research evidence that points to a progression of mechanical understanding to a biological understanding is from research on children's understanding of illness concepts, therefore it will be discussed in more depth in Chapter 2.

From the above discussion, different viewpoints on the emergence of an intuitive biology have become apparent. However, these three positions do not map very clearly onto the three theoretical approaches to domain-specificity previously outlined in this chapter. One possible reason for these conflicting accounts may be due to different authors tending to develop their own theories. This is not helpful and almost detracts from the credibility of the theories and research in this area.

Another criticism of these accounts of the development of naïve biology is that the different accounts have different criteria set out in defining biological understanding. For instance, Au and Romo (1999) want evidence that children have specific knowledge of biological causal mechanisms such as viral reproduction in illness. Carey (1985) would also like to see evidence of such causal mechanisms. However, for Keil (1992), it is enough that children can reason about biology, even if they do not know the specifics. These, he argue, come later. Furthermore, Atran (1990) cites evidence that all cultures divide the living world in similar ways as evidence of biology's innate bias. In contrast, Carey (1995) argues that this is insufficient as this ability to create folkbiological taxonomies is not domain-specific. Therefore, on the available evidence, it is impossible to claim that one theory is correct or better than another. Consensus on what construes a naïve biology, folk biology or intuitive biology would be helpful in reconciling these approaches.

1.7. Factors Influencing the Development of Biological Thought

It is promising that there has been so much research attention directed to determining where a domain of biology emerges from. However, there has not been so much interest directed towards the further development of biological thought. Carey (1985) suggests that the development of biological thought is characterised by major conceptual change or changes. Keil (1992) prefers the idea of an abstract construal of biology that becomes more concrete. However, it is not clear what external and internal factors influence this development of biological thought. From an educational point of view, if trying to create learning environments to directly manipulate children's knowledge, it is necessary to know what influences children's understanding of biology.

There are two suggestions from the literature. Springer (1999) argues that the acquisition of factual knowledge leads to the possession of a theory of biology. Inagaki and Hatano (2002) propose a more complete model of the development of biology and discuss the influence of four factors: direct experience, personification, innate constraints and sociocultural constraints.

1.7.1. A Theory of Biology through the Acquisition of Facts

Springer (1999) suggests that a theory of biology is autonomous, at least at age 4 or 5 and does not emerge from other framework theories, although it may be informed by them. He suggests that an interaction takes place between initial knowledge and the acquisition of factual knowledge. This leads to inferences being made and the acquisition of theories relating to biology. Springer focuses on a naïve theory of kinship, as he believes that children's knowledge of the family moves from social understanding to biological understanding based on genetics. This move in knowledge is believed to occur when children learn the crucial fact that babies grow inside their mothers which occurs around the age of 4 years. If Springer's theory is correct, this suggests that the provision of facts should be enough for children to derive inferences in order to construct a naïve theory of biology. Springer shows that as a result of holding certain factual knowledge, children are able to generate inductive inferences and acquire a specific theory of inheritance. (There are methodological drawbacks to this research and therefore to this theoretical position that will be discussed in more depth in Chapter 3.)

1.7.2. Experience, Personification, Innate and Sociocultural Constraints

Inagaki and Hatano (2002) give a detailed account of how children may acquire a naïve biology and the major influences in the acquisition of this. In their view, pre-school children are able to think consistently and causally about biological phenomena.

Evidence that children as young as 5 years of age possess a naïve theory of biology comes from research that found pre-schoolers can distinguish between living and non-living entities (e.g. Inagaki & Hatano, 1987). Therefore, unlike Carey, they think that young children have a distinctive biological knowledge system as opposed to a psychological one. Young children's understanding of biology is seen as qualitatively different from adults due to the paucity of young children's biology-relevant experience and specific knowledge. Inagaki and Hatano (2002) propose various influences on the development of children's thinking about biology. In their view, children construct biological knowledge using a powerful learning mechanism of selective analogy with knowledge about humans as the source, helped by innate constraints, building on their experiences and helped by sociocultural constraints.

The use of personification as analogy means children can grasp commonalities between animals and plants. Previously personification has been seen as evidence of psychological thinking about biological phenomena (Carey, 1985). However, Inagaki and Hatano (2002) believe personification is an attempt to interpret biological phenomena biologically. Personification is the extension and application of human properties and behaviours to animals and plants. This is practical as children have extensive knowledge about humans compared to scant knowledge of animals and plants. Therefore, humans function as a reference point. Research evidence shows that children do not make many errors when using personification as analogy and this may be due to the help of two constraints. The similarity constraint requires the target object to be similar to humans to allow personification to apply to it. The feasibility constraint, or factual check, checks whether personification is feasible on the basis of factual knowledge about the target object. Through these means children can generate predictions and reason about unknown target objects through reference to their knowledge of humans. Further to this, personification as analogy allows children to incorporate facts about animals by connecting them to the core of their biological knowledge, knowledge of human biology processes, thus developing a fuller knowledge of biology.

Inagaki and Hatano also propose that the acquisition and development of a naïve biology is influenced by innate constraints. Evidence for the innate predisposition to acquire a theory of biology comes from three sources. Firstly, research on infants has shown that children under the age of 3 years olds show evidence of precursors to naïve biology, by distinguishing between animate and inanimate objects. Secondly, innate constraints are strongly suggested by the universality of folkbiology. As discussed above, Atran (1998) compared Itzaj Mayas with Americans and found that they categorised plants and animals in similar ways. Finally, it is possible that there are dedicated neural mechanisms for reasoning and thinking about biology. For example, patients have been shown to have selective impairment for naming and recognising living or non-living things (Warrington & McCarthy, 1983). However, Kawashima et al. (2001) have found that although different areas of the brain are activated in the naming of plants, animals and artefacts compared to naming digits, no differences between the three categories were found. This indicates that they are not necessarily located in different areas of the brain.

A further influence on the development of biological knowledge is through direct experience. Inagaki and Hatano (2002) describe how basing biological understanding on experiences is an important part of children being considered "theory builders" (Carey, 1985; Wellman & Gelman, 1992) as they are active learners. However, today's industrialised society means that children do not often have the opportunity to gain first hand experience of the biological world. Three kinds of practice are indicated as being of particular importance to children: raising animals and growing plants (Inagaki, 1990) visiting a zoo or botanical garden (Altman, 1998); and joint reading of picture books (Gelman, Coley, Rosengren, Hartman & Pappas, 1998). Inagaki and Hatano argue that experiences such as these give children a form of contact with the natural world that helps them to construct biological understanding.

The final influence on the acquisition of naïve biology is sociocultural constraints. This account asserts that interaction with other people plays an important role in learning and cognitive development (Hatano & Wertsch, 2001). Through children's interaction with more mature members in the community or culture and activity-based experiences, they are helped to acquire naïve biology. Sociocultural contexts greatly influence what are accessible for each child in the course of development by restricting access to resources. However, not only does the cultural setting determine what experiences children have access to, it arguably shapes the interpretation placed upon these experiences. As a result, there may be some cultural variation in naïve biology (e.g. to a sociocultural theorist, even the natural kinds/artefact distinction is best regarded as a cultural construction of a central functional difference – hence its universality – which children are inducted into from a very early age in many different ways.). An example of sociocultural constraints is demonstrated by Inagaki and Hatano (1997) where they allowed children to discuss evolution with each other and found this enhanced their knowledge. The findings of this study are elaborated on in Chapter 3.

The impact of these influences on the development of children's biological thought will be considered in detail in the discussions of Chapter 3. They suggest the types of factors, i.e. experience, sociocultural influences, that have an influence on the development of biological thought. This will be used to determine possible intervention approaches that may be beneficial in improving biological understanding by showing how experimental situations can be created to provide these factors under controlled conditions.

1.8. Summary

This chapter has described children's thinking about the biological world. There are various existing theories about how and when a naïve biology emerges. Atran (1998) and Sperber propose that biology is an innate domain of knowledge that is there from birth. Likewise, Keil (1992) also believes that biology is innate but considers this understanding to be theory-like. Alternative accounts see biology as emerging from other intuitive theories at a point later in development, either psychology (Carey, 1985) or physics (Au & Romo, 1999). Various proposals about the factors that influence the development of biological thought are identified, such as the provision of factual information and socio-cultural constraints, and it is possible that they have implications for teaching about biology.

1.9. Implications for this Thesis

From the foregoing literature review, it is obvious that there are many unresolved issues regarding the nature of children's naïve biological understanding. As already stated, it is not the purpose of this thesis to attempt to resolve these debates. Despite this, the thesis will still have implications for the theories discussed in this chapter. Namely, whether children have a naïve biology, at what age this arises, whether it is theoretical and what can be used to improve their knowledge i.e. what influences and drives their understanding. In providing input on these debates, this thesis will also touch upon the bigger debate of whether cognitive development proceeds in a domain-general or domain-specific way.

There are two main points that have arisen which hold implications for the research to be reported in this thesis. Firstly, research on different areas of biological understanding frequently paints a different picture regarding the nature of children's biological knowledge. For example, investigations on the essentialist nature of children's naïve biology would suggest that children hold a framework theory of biology (Gelman, 2004). Whereas, research on children's inheritance concepts implies that children hold a series of facts about biology that are not yet integrated into a coherent theory (Solomon et al., 1996). One possibility for these discrepancies is that children's understanding of biology may be fragmented or organised into micro-theories of specific systems of knowledge. Indeed, it has been shown that this is the case with children's physics knowledge (Howe, Tolmie, Greer & Mackenzie, 1995). Therefore, when looking to improve understanding of biology, one of the aims of this thesis, it may be appropriate to look at one area of biological understanding in isolation. This is one reason why the rest of this thesis will focus specifically on children's understanding of illness. It has already been discussed that illness concepts can inform theory on cognitive development and this will be returned to in Chapter 2 where the practical benefits of research on illness will also be taken account of.

The second point to arise from the preceding discussion is the various theories of how biological knowledge arises and develops. By looking at theories of domain-specific development, there is no clear agreement on domain-specific processes of development with some theorists favouring theory building (Carey, 1985; Gopnik & Meltzoff, 1997) or RR (Karmiloff-Smith, 1992). However, discussion of theories of naïve biology reveals various influences on the development of children's biological thought e.g. through the acquisition of factual information (Springer, 1995; 1999), or sociocultural constraints (Inagaki & Hatano, 2002). These ideas will be discussed further in the context of developing intervention methods for teaching about illness in Chapter 3.

This thesis has two further literature reviews to recount before going on to report empirical work. First of all, the following chapter will examine previous research on children's illness concepts. One of the key functions of Chapter 2 will be to build on the ideas introduced in this chapter. Mainly, a contrast between the domain-general approach to illness concepts and the domain-specific approach will be highlighted and how research on children's understanding of illness can inform theories on naïve understanding of biology will also be discussed. Chapter 3 is concerned with intervention methods that have been used in previous research to improve children's understanding of biology and illness.

Chapters 4, 5 and 6 describe three empirical studies investigating what children understand about illness and whether intervention methods can improve this understanding. The final chapter is a general discussion where the findings of this work will be considered in terms of the previous work and theories discussed in the present chapter and the following two chapters.

Chapter 2:

Children's Understanding of Illness

2.1. Introduction

The previous chapter outlined contrasting theories of cognitive development and emphasised the key debate of whether development proceeds in a domain-general or a domain-specific fashion. As discussed, research on children's understanding of illness is an area of conceptual understanding that has been influenced by these different theoretical perspectives and has thus informed debate on cognitive development (Kalish, 1997). However, as mentioned in Chapter 1, children's understanding of illness is also important practically in terms of health care, education and practice (e.g. Au, Romo & Dewitt, 1999; Rushforth, 1999; Siegal & Peterson, 1999). The aim of this chapter is to review the literature on children's understanding of illness for the purpose of identifying what children know about illness and what directions future research could take.

There is a wealth of literature on children's understanding of illness. Many researchers from disciplines as varied as developmental psychology, health psychology, paediatrics, nursing and sociology have investigated what children understand about illness. However, such a variety of disciplines has led to a disparate literature. As a result, the various attempts to review this literature have also come from different disciplines and therefore have different orientations specific to their research agenda. Thus, it is important to take a novel approach to reviewing the literature on children's understanding of illness to provide the necessary background for the empirical work of this thesis.

For this purpose, this chapter will cover three different areas of research on children's understanding of illness. Frameworks adopted by previous reviews in developmental psychology have been adapted here to fit with contemporary theories of domain-specific development and more recent research on illness understanding. First, the domain-general approach to children's understanding of illness will be covered. This approach has been covered extensively in previous reviews (e.g. Bibace, Schmidt & Walsh, 1994; Eiser, 1985; Jordan & O'Grady, 1982) and is included here: firstly because it gives an outline of the development of illness concepts and secondly as it shows how research on illness concepts can be influential in informing education and health practice.

The second approach included in this chapter is the domain-specific approach. This is similar to the "cognitive science" category of research studies identified by Bibace et al. (1994) but also considers the recent wave of research on children's intuitive biological understanding as described by Kalish (1999) and Siegal and Peterson (1999) in their reviews. This is the approach that is particularly crucial in this thesis as it is aiming to adopt a domain-specific approach in designing intervention methods to improve understanding of illness. Therefore, the way in which children's cognitions of illness develop and how they are influenced is particularly important to the intervention studies reported in Chapters 5 and 6.

The final approach comes from health psychology. Within health psychology there have been some strands of research that are identified as important to this thesis. In particular, understanding of specific illnesses and how experience impacts on children's knowledge of their illness. Further, research on adults' illness cognitions will be briefly considered. This approach adds to the previous two orientations as it provides information on specific illnesses and cognitive consequences of the experience of illness that the developmental approaches lack to a certain extent.

Criticisms of the extant research on illness concepts will be discussed. The most important of which is that these individual approaches do not provide the complete story of what children understand and even when they are considered together, there are still gaps in knowledge. As a result, a rationale for the first empirical study of this thesis is created.

2.2. Why Study Illness Concepts?

Children's understanding of illness is important from both a theoretical and practical perspective. It has already been discussed in Chapter 1 how understanding of illness can be used to inform more general theories of cognitive development. For example, early research attempted to place children's concepts of illness within Piaget's theory of development and therefore concluded that development proceeds in stages. More recent research, considers illness as an important part of understanding in the domain of biology and investigations on illness concepts have been used to supplement key arguments in this area. For example, as discussed in Chapter 1, when children acquire a naïve theory of biology; and whether an understanding of biology arises from an understanding of psychology, physics or is present at a pre-school age. These debates and the contribution of research on illness concepts will be discussed fully in this chapter.

From a practical perspective, research on children's understanding of illness can be used to generate age-appropriate explanations for children affected by illness. This is especially pertinent in health care settings as children have frequently been shown to display unnecessary fear, guilt and anxiety before receiving treatment for illness (Whitt, Dykstra & Taylor, 1979). Perrin and Perrin (1983) suggested that child health care providers might communicate more effectively with child patients if they become more familiar with how much children are capable of understanding about illness. They found that information being given to children by health practitioners was pitched at mid-school age irrespective of age, cognitive ability or existing knowledge. Even in the present day, evidence suggests that practitioners may be offering children inadequate explanations of their illness and underestimating how much children understand (Alderson, 1993; Rushforth, 1999). The benefits of knowing what children are capable of understanding and providing age-appropriate explanations are two-fold: this will not only reduce fear but also open up the possibility for them to become active participants in decisions surrounding their care. This is relevant to the idea that children have a right to be informed about their illness and treatment procedures.

As well as benefiting health care providers, a full analysis of children's understanding of illness could benefit health education programmes used in schools (Bibace & Walsh, 1980). Health education is important as children need to develop positive attitudes to self-care and health behaviour, not only for their immediate health status, but also because these attitudes are associated with positive health beliefs in adults (Mechanic, 1979; Lau, 1982). It has been shown that health education can improve knowledge of cancer prevention (Schonfield et al., 2001), nutrition (Cullen et al., 2004), asthma (Bartholomew et al., 2000; McGhan, Wells & Betus, 1998) and AIDS (Au et al., 1999; Sigelman et al., 1996) indicating that age-appropriate education programmes can be successful. Chapter 3 will discuss this in depth by considering the different intervention methods that have been used with illness concepts and other biological concepts. It is clear that the practical need to inform children about health and illness is well-recognised. However, as will be discussed in Chapter 3 the issues of when, how and what to teach are more open. Research on illness concepts is of value here as it can highlight what children understand at different stages of development and help pitch educational materials at the right level.

2.3. The Domain-General Approach to Children's Understanding of Illness

The earliest work on illness concepts adopted a domain-general approach and was based on the work of Piaget. Piaget (1932) claimed that children rely on immanent justice as an explanation of unfortunate events i.e. they are likely to judge such events as a consequence of misbehaviour. Immanent justice has also been found to be given as an explanation for illness by young children in several empirical studies (e.g. Beverly, 1936). For example, Brodie (1974) found that anxious children were likely to see their illness as punishment and Perrin and Gerrity (1981) reported that bad behaviour was used as an explanation for subsequent illness. Langford (1948) suggested that this tendency to see illness as punishment may be due to the language parents use in talking to their children about illness e.g. parents frequently scold children for eating certain foods and tell them that this will cause an upset stomach.

However, children were also shown to hold other beliefs about the causality of illnesses, such as germs being a potential cause of illness (Perrin & Gerrity, 1981). Kister and Patterson (1980) compared children's use of contagion and immanent justice as explanations of illness. Children aged between 4 and 10 years were asked questions about a contagious illness (cold), a non-contagious illness (toothache) and an injury (scraped knee). They found that the older children used contagion as an explanation of illness but the younger children were likely to use immanent justice as an explanation for all illnesses. Furthermore, the younger children frequently over-extended contagion as an explanation for both toothache and scraped knee.

Piaget's stage model of cognitive development also had a strong influence on research on illness understanding. Early research on children's illness concepts attempted to plot the development of concepts of illness in line with these stages (e.g. Bibace and Walsh, 1981; Perrin and Gerrity, 1981). Hence, it was argued that children's understanding of illness was limited. Bibace and Walsh (1981) conducted a series of interviews based on children's understanding of several common illnesses such as the cold, heart attack and measles. They asked a comprehensive set of open-ended questions including questions on definitions of illness and causes of illness. The use of this Piagetian "clinical method" was believed to tap cognitive processes and result in meaningful responses. Responses were coded into three major types of explanation consistent with Piaget's stages of development, prelogical, concrete logical and formal logical. Within each of these stages, two subtypes of explanation were distinguished. The explanation types generated by Bibace and Walsh's research are explored in depth below:

Prelogical Explanations: Children in the pre-operational stage, between 2 and 7 years of age, were argued to be egocentric and unable to distance themselves from their environment. As a result, their causal explanations of illness were said to be heavily influenced by the immediacy of their perceptual experiences. "Phenomenism" described the most developmentally immature category of explanations as these types of response show no ability to differentiate between cause and effect. A more mature type of explanation from children in this stage was "contagion" where the cause of the illness is identified as being from other people but only proximity links the cause and the illness.

Concrete-logical Explanations: Piaget (1926) described the main development shift in the concrete operational stage as the accentuation of the differentiation between self and other. This allowed children aged 7 to 10 years to distinguish between internal and external influences on the self. This lead to more sophisticated explanations being offered for illness based on "contamination". Here, the child can distinguish between the cause and the effect of the illness. The cause is viewed as something external to the child, e.g. person, object or action that has a bad or harmful quality for the body. If this person or object comes in contact with the child, they become contaminated. More mature children in this stage offered "internalisation" explanations where the illness is located inside the body and the cause is external. The external cause, either a person or object, leads to illness by process of internalisation e.g. swallowing. However, illness is still described in vague terms with confusions about internal processes and organs.

Formal-logical Explanations: The highest level of explanation was at the formal logical stage. Piaget described children aged 11 years to be capable of advanced reasoning. Children in this stage were described as able to give "physiological" explanations of illness which correspond to formal theories of infection, health maintenance and treatment. An even more mature understanding of illness was characterised by "psychophysiological" explanations where the child is further aware of the possible psychological causes of illness.

Perrin and Gerrity (1981) also plotted the development of illness concepts in a similar fashion. They investigated the understanding of illness causality along with more general tests of cognitive development and found that the development of illness concepts followed a developmental sequence in line with other areas of cognitive development between the ages of 5 and 13. They argue that their data support the idea that development proceeds in parallel for different areas of cognition and understanding. For example, younger children between the ages of 5 and 7 years define illness in terms of external signs of the illness such as being told to go to bed. At the concrete operational stage, where children are able to understand things from multiple points of view, they start defining illness in terms of its symptoms. They see prevention of illness as a matter of simply staying away from people who are ill and therefore have germs. By age 13, children are expected to have reached the formal operational stage of thinking and should be able to reason about illness in abstract terms. Perrin and Gerrity found that very few children were able to do this for illness and the most difficult aspect for them to understand was prevention.

These accounts have provided very detailed descriptions of the developmental progression of illness concepts. Both these studies show that children's understanding of illness becomes more sophisticated with age in line with the development of other areas of cognition. This supports predictions made by Piaget regarding cognitive development being domain-general. However, despite recognising development in children's understanding of illness, it was also assumed that any misconceptions or partial understanding of illness were a consequence of cognitive immaturity which could only be overcome by advancement in chronological age. This implied that children could not be taught about illness or told details of their condition that was beyond their cognitive capabilities at a certain stage which had implications for health practice and health education (Eiser, 1989).

Stage theories of illness have shown their importance as they have been used as the background for a lot of further studies on illness understanding (e.g. Banks, 1990; Crisp, Ungerer and Goodnow, 1996; Koopman, Baars, Chaplin & Zwinderman, 2004) and their importance in first recognising that illness concepts could be studied from a developmental perspective is still acknowledged today.

2.4. The Domain-specific Approach to Children's Understanding of Illness

As mentioned in Chapter 1, recent theorists have argued that children's development is likely to proceed in a domain-specific fashion (Karmiloff-Smith, 1992; Wellman & Gelman, 1992; Wellman & Inagaki, 1997). As well as providing an alternative account to the domain-general theories of children's development, this has also led to a different approach of researching children's illness concepts. Additionally, a case was made in Chapter 1 for the relevance of illness concepts to broader theories of cognitive development. This section covers the domain-specific approach to illness concepts. Firstly, it will consider how this new approach to children's illness concepts arose. Then it will discuss research which suggests children's illness understanding is a part of their intuitive biological knowledge approach. Finally, the structure of illness concepts will be considered.

Eiser (1989) was one of the first to suggest a new theoretical approach to children's understanding of illness, despite her earlier pro-Piagetian standpoint (Eiser, 1985). She was disillusioned with the previous theoretical framework, which was being challenged so fiercely within developmental psychology as a whole that she felt it was inappropriate to still apply the model to work on illness. She proposed links between Carey's theory of conceptual change that was described in Chapter 1 and the development of illness concepts. Carey (1985) saw a change in reasoning from psychological to biological not only as a result of cognitive development but due to an acquisition of knowledge and structural change. Although Carey did not consider illness concepts in her theory, Eiser suggested that the implications were important.

Around the same time, Siegal (1988) conducted a study that challenged the findings of earlier research methodologically. He posited that children may not lack understanding as suggested by researchers such as Bibace and Walsh (1981) and Kister and Patterson (1980), rather they may have misinterpreted the experimental situation as a result of inappropriate methodologies. Therefore, he created more child-friendly methodology to investigate children's understanding of contagion. Pre-schoolers were asked to judge whether a puppet was accurate in their explanation of why they got ill. The children were not likely to advocate immanent justice as a reasonable explanation of illness and in contrast to Kister and Patterson (1980), it was also found that they were not likely to overextend contagion to toothache and scraped knee.

These two papers helped change the face of research into children's illness concepts. The constraints imposed by stage theories were lifted giving way to more generous theoretical frameworks to work from. The development of new methodologies meant that research could turn to looking at what they did understand rather than what they did not. Most importantly, however, children were credited with more capability of understanding than previously thought.

It was outlined in Chapter 1 that illness is an important area of children's understanding of biology (Siegal & Peterson, 1999). However, there is a lack of consensus on what a biological understanding of illness would entail. It can broadly be characterised as having four components: acquisition, symptoms, treatment and subsequent contagion, with germs as the causal agent that links these components into a coherent understanding (Solomon & Cassimatis, 1999). Therefore, conceptions of illness provide an excellent opportunity to study children's reasoning about causal mechanisms in biology, whether their ideas are organised into a coherent model of illness transmission and the age at which this understanding becomes "biological". However, what counts as biological understanding will depend in part on the criterion set out by the different researchers, e.g. possessing domain-specific facts (Springer & Ruckel, 1992; Kalish, 1996a) or specific understanding of the mechanisms involved in the causal processes (Au & Romo, 1999), which holds implications for these debates.

One study which demonstrates nicely that illness is an area of biological understanding is that of Raman and Gelman (2004). They interviewed Indian and American preschoolers and asked them to choose between biological, moral, psychological and irrelevant explanations for different illnesses. Results indicated that the biological model was the most prominent across both cultures. However, cultural differences were found as Indian participants acknowledged significantly more moral and psychological causes than Americans and Americans made explicit reference to germs whereas Indians referred to contamination. This is an important study as it not only demonstrates that illness is universally a biological phenomenon for children but it also shows how vital it is to take a cultural perspective.

However, it may be slightly restrictive to confine a biological understanding of illness to contagion as this excludes understanding of infectious illness and organic disease. In fact, most studies looking at children's understanding of illness considers diseases that are transmissible by contagion, e.g. runny noses and sore throats. This leads to the variation involved in the nature of transmission of illnesses, for example, through air, water, bodily contact, being somewhat neglected by this type of research. It would be relevant to look at the various vectors involved in transmission but this would involved a level of complexity beyond the basic notion of transmission via biological organisms on which this thesis, and most of the previous research, is focused.

2.4.1. Illness Concepts as Part of an Autonomous Theory of Biology

As illness is considered to be a biological concept, research on illness concepts can contribute to the discussions raised in Chapter 1 regarding the origin and onset of a naïve understanding of biology. Most research that looks to determine whether biology is an autonomous theory is conducted with pre-schoolers and investigates their ability to distinguish between the living and non-living worlds (see Chapter 1). However, there is also a limited body of research on understanding of illness. For example, Kalish (1996a) asked children and adults to make judgements about characters suffering from various symptoms of illnesses. Participants were asked to indicate whether or not the character would have a fever, need medicine from a doctor, be better soon, and, most crucially, be contagious. The findings showed that preschoolers were likely to predict illness when germs were present and it is therefore likely that they see germs as the mechanism of illness causation. A follow-up study found that children as young as three years recognised the causes of illness were invisible although they did not know what germs were. Kalish argued these results demonstrated that preschool children could reason about a specific hidden mechanism and that they have some theory-based knowledge in the domain of biology.

Likewise, Raman and Gelman (2005) reported that preschoolers have an understanding of contagion and genetic transmission of disease. They used a classic "adoption" style task where children were described scenarios in which a baby was born to a couple and immediately after birth went to live with another couple. The vignette then described either a genetic disorder or a contagious illness that either the biological parents or the adoptive parents had and the participants were then asked whether the child would have the disorder or illness or would be okay. Through a series of studies they demonstrated that pre-schoolers were able to attribute distinct modes of transmission for the genetic disorders and contagious illnesses. These findings are argued to be consistent with the suggestion that a theory of biology is an early, autonomous competence rather than an offshoot of some other theory. It is important to note, however, that in both these studies, children did not spontaneously suggest germs and genetic transmission as mechanisms for illness as the methods used were forced-choice.

2.4.2. Illness Concepts as an Offshoot of Psychology

An alternative origin of an intuitive understanding of biology is that it arises from a naïve psychology (Carey, 1985). This is supported by research findings that show that children tend to explain biological phenomena such as life, death and hunger in terms of social/psychological explanations (see Chapter 1). Carey (1985) does not use any specific illness examples but the immanent justice explanations given by children in the earliest illness research are essentially a social/behavioural explanation for illness (Kister & Patterson, 1980). However, more recent work has shown that children do not favour immanent justice as an explanation of illness causality. As already mentioned, Siegal (1988) showed that pre-schoolers preferred biological explanations and rejected immanent justice explanations for colds, toothache and scraped knee.

Springer and Ruckel (1992) report further empirical findings in support of this. They changed the questioning method used in the original Kister and Patterson (1980) study from a "retrospective" technique to a prospective questioning method, i.e., instead of telling a story about a child who had misbehaved and later got ill, they told stories about children who had misbehaved and then asked if they would get ill. Four different items were used to see whether children preferred immanent justice (a social construct) or contact with germs (a biological explanation) as a more plausible explanation of illness. Their results suggested that the preschoolers do not adhere to immanent justice explanations and they frequently mentioned germs in their explanations of illness. Therefore, the authors concluded that children think about disease in biological rather than social terms.

However, the disparity between Piagetian research and this more recent work may be partly due to the sample population. Springer and Ruckel (1992) used a sample comprising of healthy children compared to early research which has mainly included children with a chronic illness (e.g. Beverley, 1936). For this reason, Springer (1994) conducted a further study that investigated immanent justice beliefs in children with cancer and healthy children. Given the high rate of rejection of immanent justice in Springer and Ruckel's study, immanent justice explanations were made more tempting by describing prolonged instances of misbehaviour rather than specific incidents. Results showed that pre-schoolers with cancer were at least as likely as healthy children to reject immanent justice as an explanation of illness. This extends the conclusions of Springer's previous work by showing that the children were not swayed by long periods of misbehaviour and also by describing differences between chronically ill children and healthy children.

Therefore, research that looks at the causality of illness concludes that children do not prefer social explanations to biological explanations. However, there are other ways of distinguishing between the social and biological factors of illness. Kalish (1997) told children stories in which a character did or did not know if food was contaminated, and did or did not eat the food. Responses showed that children said that the character was more likely to get sick than depressed if they did eat the food but did not know it was contaminated, and also that the character would be more likely to get depressed than sick if they knew the food was contaminated but did not eat it. This indicates an understanding that emotional effects are more likely to occur from knowing the food is contaminated and the physical effects are more likely to arise as a result of eating the food. Kalish (1997) concluded that children are capable of distinguishing between the domains of biology and psychology when thinking about illness.

Further evidence regarding whether psychological and biological understanding is entwined or separate is provided by Keil et al. (1999). They asked children to predict the likely route of transmission for novel mental and physical illnesses. Correct answers were judged to be ones where the child matched the mental affliction with the social interaction, or the physical affliction with the physical interaction. The results were interesting as data from the youngest age group (3-4 years) suggested that children were able to match each kind of illness with the most likely method of transmission. However, in the older age groups, children appeared to have thought that physical contact was necessary to catch both biological and mental afflictions. Children's responses suggested that the change was caused by a move from an abstract understanding of biological disorders to a more concrete model involving detailed understanding of the mechanisms involved in illness transmission. However, as the method of transmission in all cases is seen as the transmission of germs through physical contact, this finding agrees with the conclusion that understanding of biology is separate from psychology.

Overall, the results from these studies strongly support the suggestion that children are capable of distinguishing between psychological and biological factors of illness. The authors of these studies conclude that as children do not appear to reason about illness in psychological terms, they must possess an autonomous theory of biology. This would suggest that biological understanding is innate or at least present in pre-schoolers. However, an alternative explanation is that children do not have a coherent understanding of biology and rely on mechanical reasoning to explain biological phenomena (Au & Romo, 1999; Baron-Cohen, 1997). Indeed, alternative explanations based on mechanical or physical reasoning for the above findings of these studies can be provided and are just as convincing. Springer and Ruckel (1992) have shown that social explanations of the causality of illness are rejected and therefore assume that biological reasoning is dominant. However, they have described the preferred explanations of illness as such:

> …the illness is induced through contact with material agents such as germs or poison, or through some other physical means, and not through intentional states or other social influences…Overall, these data support the idea that young children prefer biological and reject social construals of biological phenomena. (Springer & Ruckel, 1992, p.439).

The conclusion drawn from these results is felt to be very optimistic. Although a clear rejection of psychological explanation of illness is present, it is not obvious that children are capable of understanding illness in biological terms. Instead, attention is drawn to the idea that illness is caused by physical means, suggesting an understanding based on naïve physics rather than biology. Similarly, Keil et al.'s (1999) findings can be explained in this way. Although the pre-schoolers in this study acknowledge the role of germs in illness, it is not clear whether they see germs as biological entities which are alive and whether they fully understand the role they play in contagion and contamination. In contrast, children have been shown to have a detailed understanding of physics and the mechanics of objects and movements (Baillargeon, Kotovsky & Needham, 1995) so it is not unreasonable that this understanding and knowledge may be used to reason about biological mechanisms.

2.4.3. Illness Concepts as an Offshoot of Physics

In order to provide evidence that children invoke mechanical causality in explaining illness, Au and Romo (1999) interviewed children aged 5 –10 years using an open-ended questioning method. Questions were asked about why there is an incubation period between contracting the illness and showing symptoms (the understanding of reproduction of germs is often considered evidence of a biological model of understanding (Kalish, 1999)) and also why a child would feel ill over his whole body. The responses were coded according to whether they were biological or mechanical. This led to a very small proportion of children (6%) being credited with a biological understanding of illness. Most of the children explained things in terms of mechanical causality such as it took a few days for him to get ill because "it takes a while for the germs to get in" (p.375). Therefore, Au and Romo conclude that children do not possess the ability to reason biologically about phenomena and cannot talk about biological causal mechanisms. However, it can be noted that the coding scheme they use classifies many things as mechanical that other studies would say are biological and even the authors admit they may be being "too harsh" (Au and Romo, 1999, p. 396). An additional point is that this study uses open ended questioning methods which have been traditionally criticised for not allowing children to show the full extent of their understanding (Siegal, Waters & Dinwiddy, 1988).

However, research that uses forced choice methods has also suggested that children may think about illness according to a physical model. Solomon and Cassimatis (1999) asked pre-schoolers to judge whether someone would be contagious to others due to contact with a biological agent, e.g. germs, or a non biological agent, e.g. pepper. They found that pre-schoolers did not distinguish between the types of agent in determining whether someone was contagious to others. Further studies indicated that pre-schoolers did not consider germs as living things and biological causal agents. These results may indicate a possible lack of discrimination between physical and biological modes of explanation.

2.4.4. Development of a Biological Understanding of Illness among Older Children

These studies have mainly focused on preschoolers and when an understanding of biology comes to the fore. More information on the development of illness concepts throughout later childhood is obtained from research that has based investigation upon Carey's theory of conceptual change. One of the first studies to adopt this approach was Hergenrather and Raboniwitz's (1991) research into the organisation of children's knowledge of illness. They compared the structure of children's knowledge of illness across three age groups, 6/7 years, 9/10 years and 13/14 years. Younger children appear to organise their understanding of illness in terms of associated behaviours, for example, being in bed or having a temperature taken were seen as signals of being ill. By contrast, 13 year old children reorganised their conceptions of illness in terms of more internal processes such as causes, symptoms and treatments. The description of the development of children's knowledge of illness is not dissimilar to that described by Perrin and Gerrity (1981). However, rather than the development of illness concepts involving cognitive maturity and passing through a series of developmental stages, Hergenrather and Raboniwitz (1991) describe development as involving a conceptual change and reorganisation of concepts to reach the highest level.

Similarly, studies that have looked at the development of specific illnesses rather than illness in general have found their results do not fit a Piagetian model of development. Sigelman, Maddock, Epstein and Carpenter (1993) were interested in plotting the development of children's understanding of AIDS, an area of research where previous studies did not base their hypotheses or methodologies on any theory of development. To take a Piagetian stage-like approach was not found useful as what was of especial interest to the researchers was not simply cognitive maturation but the developmental changes in the content and organisation of knowledge. Understanding of AIDS was compared to understanding of cold, another contagious disease and understanding of cancer, a non-contagious disease. The findings show that specific knowledge of each disease became more differentiated with age supporting the idea of specific areas of understanding for different diseases. Moreover, the tendency to infer properties from colds and AIDS to cancer was argued to be evidence that children are guided by an intuitive theory of contagion as it indicates that if children lack knowledge of a disease they are likely to assume it is contagious.

Charman and Chandiramani (1995) also considered specific illnesses and looked at children's understanding of chicken pox and of depression, thereby comparing a physical illness to a psychological state. They found that there were developmental changes between the ages of 5 and 9 years with older children having a more coherent understanding of illness. It is argued that the findings of this study do not fit in with a neo-Piagetian framework of illness understanding. For example, the children in this study did not seem to make the egocentric error of overextending contagion to depression. In addition even the younger children were able to describe the illnesses using non-observable symptoms. Instead, Charman and Chandiramani appeal to Carey's (1985) theory of conceptual change to support their findings. The 5 year old children were shown to have some basic knowledge and this knowledge appears to have been built upon to become more sophisticated. In addition, as the children were shown to have differing levels of knowledge of chicken pox and depression, this indicates that it is not a domain-general phenomenon and that reasoning is not characterised and fixed at one particular point in development.

These studies show the value of taking a domain-specific approach to understanding of illness for a range of illness(es) and illness processes. It builds on research on biological concepts performed with preschoolers and shows how understanding of illness develops in later childhood. Like research from a domain-general perspective, there is clear development of illness concepts. However, it is not seen as just cognitive maturation and the children are able to give better explanations of illness than those that mention magic or immanent justice. These results support Sigelman et al.'s (1993) proposition that children construct coherent theories of disease and acquisition of knowledge shapes the evolution of these theories. In particular, it seems as though there is some sort of conceptual change in understanding of illness at some point during childhood. However, there is little consensus at the age at which this may occur indicating the need for future research in this area. A clearer picture of the ages at which children understand different things about illness would have obvious benefit for any attempts to improve understanding. This would help ensure that intervention methods were designed for appropriate age groups.

2.4.5. Structure of Illness Concepts

One final unresolved issue in this area is the structure of children's illness concepts. It is possible that children have a theoretical understanding of illness (Kalish, 1996a). As outlined in Chapter 1, a theory of illness would enable children to predict future events, interpret evidence, and provide explanations both of illness and novel situations (Gopnik & Meltzoff, 1997). This has implications for domain-specific theories of cognitive development described in Chapter 1 advocated by Wellman and Gelman (1992), Carey (1985), Karmiloff-Smith (1992) and Gopnik and Meltzoff (1997). However, this is also important in terms of education as the nature of children's illness concepts may influence what different teaching approaches are successful in leading to improvements in knowledge. If children's knowledge is theoretical, then it is unlikely to progress through a process of knowledge enrichment. Alternatively some process of domain-specific development would be necessary, such as conceptual change (Carey, 1985), theory building (Gopnik & Meltzoff, 1997) or representational redescription (Karmiloff-Smith, 1992). In this case, specialised intervention approaches that encourage such learning would be more successful than those that merely promote enrichment. It will be the objective of Chapter 3 to discuss this further, in terms of intervention. In this present section, discussion will be devoted to the structure of illness concepts.

There are two alternative viewpoints about the development of a theoretical understanding of illness. Keil et al. (1999) have argued that children's understanding of illness proceeds from an abstract understanding to a more specific understanding. Alternatively, Kalish (1999) proposes that children move through a series of models of infection that become more biological with development.

As alluded to in Chapter 1, it is possible that children have abstract knowledge within the domain of biology with little or no understanding of specific biological mechanisms (Keil et al., 1999; Simons & Keil, 1995). By this account, it appears as though abstract principles are among the first to be learned. Then, throughout development, specific information is learned and incorporated into this existing framework. Therefore, before learning about a particular mechanism of contagion, children might have some strong sense about more general causal properties of a domain of biology. Evidence in support of this view is provided by Keil et al.'s (1999) finding that children limit contagion to physical/biological attributes, as discussed in the previous section. Children were asked if a novel mental illness was likely to be transmitted through germs and a U shaped developmental curve in responses was observed with younger and older children giving more correct answers than the middle age group. This is argued to be evidence of an abstract to concrete shift as the youngest children perform well as they rely on an abstract notion that physical and social afflictions are fundamentally different and therefore likely to be caused in different ways. However, the drop in performance observed in the middle children is explained by them having an understanding of contagion but overgeneralising this to explain the transmission of social diseases as well as physical illnesses. The older children, however, have developed a more accurate notion of a mechanism of contagion so can distinguish between social and physical illnesses and perform better.

An alternative viewpoint is provided by Kalish (1999) who suggests that children's understanding of specific details is more important than their abstract understanding within a domain. He has dedicated a number of studies into determining how children understand contagion and whether this understanding is theoretical (Kalish, 1996a, 1996b, 1997, 1999). The earliest findings identified what type of concept; nominal, property cluster or natural kind, children's conception of illness could be characterised as. Kalish (1996a) studied the types of inferences children were able to make from the properties of illness and concluded that children's concepts of illness correspond to a property cluster where both symptoms and causes contribute to their identifications of illness. However, there was also evidence that children linked these concepts together into a theory, making their conception of illness more like a natural kind and suggesting that children's knowledge of contagion was indeed organised by a theory-like structure.

However, there has been direct disagreement with this viewpoint. Solomon and Cassimatis (1999) argue that children's knowledge of illness is incomplete and not organised in a coherent, theory-like manner. Their research and previous research clearly demonstrates that children have some knowledge of contagion, symptoms and germs but in order to achieve a biological germ theory of illness, children's understanding of illness needs to undergo a conceptual reorganisation, similar to that described by Carey (1985). Before this biological understanding is realised though, it is likely that children hold a coherent model of physical infection. Kalish (1999) has reassessed his initial viewpoint that preschoolers have a theoretical biological understanding and has identified different infection models that children may hold at different stages of development.

The most basic model is an associational model of infection, which the domain-general theorists would suggest characterises children's illness understanding (e.g. Bibace & Walsh, 1981). An example of evidence that children have an associational understanding of infection is that they view all illnesses as contagious (Kister & Patterson, 1980). However, more recent research suggests that preschoolers have a physical view of infection as their predictions of illness are not based on simple associations and frequently involve a concept of a mechanism of illness transmission. Although children often see germs as a mechanism of infection, they also see other physical entities as causing illness. Solomon and Cassimatis (1999) finding that poisons, as well as germs, were viewed as mechanisms of contagion indicates that it is more likely that these children hold a model of physical infection than a biological model.

A more formal scientific biological model of infection would require some additional knowledge above and beyond a physical model. Specifically, Kalish's third model of infection is a biological model where there needs to be knowledge of the living nature of germs, and the way germs interact with the body to produce symptoms and eventually recover. The fourth model is a differentiated biological model and agents of infection are understood to come in distinct types, species with unique attributes. These models are believed to be theoretical as children's knowledge has become more consistent and coherent, which are key aspects of theoretical understanding (Gopnik & Meltzoff, 1997).

It is possible to describe a developmental sequence of these infection models progressing from simple associational to biological. Similar to Piagetian stage models, this seems to progress in a fixed invariant sequence. However, the cognitive changes involved in the transition between stages are not thought to be domain-general changes in the organisation of thought but more domain-specific changes in specific knowledge relating to germs, the body and illness. A higher stage is not seen as reflecting superior logic or more sophisticated thinking, instead, it is considered to consist of more knowledge about the biological mechanisms and processes. However, it is not clear at what age or developmental stage children could be expected to progress between the models. Kalish (1999) suggests that preschoolers hold a physical model of infection and predicts that they will be developing biological models of infection in middle childhood. However, more research is needed to ascertain this. In addition, it is likely that there are ways of assisting this transition to biological thinking through educational programmes or personal experience that have yet to be considered.

These theories of the structure of illness concepts are important but they only consider children's understanding of contagion and contagious illnesses, thereby neglecting non-contagious illnesses and injuries. Williams and Binnie (2002) attempted to provide a more unified picture of children's conceptual understanding of illness by including non-contagious illnesses and injuries in their study. They interviewed four and seven year olds about a range of illnesses and illness processes and concluded that there might be three separate reasoning systems associated with illness. One is a theoretical framework that covers contagious illnesses and germ theory. The second is separate areas of understanding linked to experience of illnesses such as asthma which may not be incorporated within a broader framework of understanding. The third is a behavioural understanding of injuries where the biological mechanisms involved are less of a focus than the behaviours which lead to injury (see also Coppens, 1986). This leads to the conclusion that children's understanding of illness may be fragmented with different types of illness being understood in different ways. If children understand different illnesses according to separate systems of understanding, it is therefore likely the processes involved in learning about these illnesses may be different. This has implications for teaching children about illness.

2.5. The Health Psychology Approach to Children's Understanding of Illness

In this section the contribution of health psychology to understanding what children know about illness will be considered. This research is mainly concerned with children with a chronic illness and the understanding of their condition (Eiser, 2003). Therefore, it differs from the cognitive developmental literature in its sample population, methodology, aims and focus. However, despite being difficult to reconcile with other research, relevant work will be considered in this chapter as it may be especially useful in highlighting how children define health and illness and what they understand about specific illnesses, areas somewhat neglected by the cognitive developmental literature. Health psychology also looks at what adults understand about illness and the relevance of this research for children's illness concepts will be considered.

One important aspect of health psychology research is investigating how children define health and illness. Early studies found that health was generally defined as in a variety of ways relating to behaviours such as eating and exercise (Byler & Lewis, 1969; Eiser, Patterson & Eiser, 1983; Natapoff, 1978) and definitions of illness were mainly based on symptoms (Millstein, Adler & Irwin, 1981). However, there has been little attempt to integrate or compare children's definitions of health and illness. An exception is Millstein and Irwin (1987) who compared concepts of health and illness and found they become more polarised during adolescence. Additionally, Schmidt and Frohling (2000) investigated definitions of health and illness in German children aged 5 to 16 years. They argued that adequate definitions of health encompassed more than just an absence of illness. They found that describing negative aspects (e.g. absence of illness) decreased with age and describing positive aspects (e.g. positive mood) increased. In Schmidt and Frohling's study, illness was frequently described in terms relating to symptoms and a general feeling of being unwell; developmental changes were reflected in the number of aspects that were mentioned. The importance of the finding that health and illness are not understood to be opposites of each other indicates that health and illness should be considered as separate concepts by health educators and practitioners. However, for this to become practical, future work needs to extend the age ranges used as Millstein and Irwin (1987) did not look at early childhood and children's concepts of health and illness.

A further issue in the health psychology research is how children understand specific illnesses. There is a large amount of literature on how children with chronic illnesses understand their condition and how this understanding influences their behaviour, preventative strategies and compares to a control group. The types of illnesses investigated includes juvenile rheumatoid arthritis (Berry, Hayford, Ross, Pachman & Lavigne, 1993), diabetes (Rubovits & Siegel, 1994), cancer (Chin et al., 1998) and asthma (Ireland, 1998). McQuaid, Howard, Kopel, Rosenblum and Bibace (2002) provide a good example of how the development of illness concepts is related to health issues such as preventative measures and behaviour. They interviewed children with asthma and found that factual knowledge and conceptual sophistication of reasoning about asthma are related to age in children. Children with asthma and their parents have higher conceptual reasoning regarding asthma than headache, and the severity of asthma may be associated with higher conceptual sophistication. Importantly, more sophisticated concepts of asthma were associated with more frequent use of preventative strategies indicating the necessity of educating children about their condition. This supports the hypothesis that repeated experience and education may lead to more advanced reasoning, this is an important notion that will be revisited in more depth in Chapter 3.

Research on adult's understanding of illness is relevant to this review as it introduces further important dimensions of illness. Unlike most research with children, it is not concerned with plotting the development of what adults understand about different conditions. Instead, research determines how adult's illness cognitions are related to symptom perception and coping behaviour. Adult's understanding of illness has been investigated through interviews (Leventhal, Meyer & Nerenz, 1980; Leventhal & Nerenz, 1985) and experimental techniques (Bishop & Converse, 1986; Lau, Bernard & Hartman, 1989). Both methods have provided support for the presence of five cognitive dimensions of illness: identity (definition and symptoms) of illness, the causes of illness, the timeline, the consequences, and whether it is controllable and curable. These illness cognitions function to help adults cope with their illness, understand their illness and help them to identify illness onset (Ogden, 1996). This framework of illness dimensions broadens out the research possibilities for those working with children from a focus purely on causes and contagion to a consideration of a range of possible illness concepts.

2.6. Criticisms of the Research on Children's Understanding of Illness

2.6.1. The Domain-General Approach

The domain-general approach has been criticised for both methodological and theoretical reasons. Burbach and Peterson (1986) conducted a review of the cognitive developmental literature on illness concepts and concluded that although the literature had added to knowledge on children's understanding of illness, better methodologies were needed before the research could be utilised in health care settings. Their methodological criticisms focused on issues such as reliability of coding scales, validity of the interviews and inadequate descriptions of methodologies. For example, Bibace and Walsh (1980; 1981) offer no statistical analysis in support of their framework (Eiser, 1989) which is unsatisfactory as this framework was, for a long time, accepted as describing the development of illness concepts.

Further criticism focuses on how "child-friendly" the methodologies were. Bibace and Walsh (1981) used a clinical-style interview technique which involved prolonged, direct questioning. This type of procedure does not usually allow children to display their full understanding (Siegal, Waters and Dinwiddy, 1988) as it places too many demands on the child. Alternatively, Kister and Patterson (1980) used a forced choice methodology which pre-schoolers would find easier to respond to but the questions were very leading. For example, "Once a boy your age disobeyed his mother. Well, that afternoon he got a cold. Do you think he got a cold because he disobeyed his mother?" It is hardly surprising that children as old as 7 years answered "yes" to this question. Not only is the question highly leading but no other option is offered so the explanation based on immanent justice is salient to the child. It is also possible that children could believe there to be a moral to be had in the story and answer accordingly.

There are also limitations in the type of questions asked. As this review has shown, children are mostly asked about the causality of illnesses such as colds. This neglects other features of illness such as time course and recovery (see also Williams & Binnie, 2002). Also, the focus on causality and contagion means that most research looks at contagious illnesses rather than non-contagious illnesses and injuries. Indeed, the few studies which have included non-contagious illnesses or injuries have done so only to determine if contagious explanations are overextended (e.g. Kister & Patterson, 1980), not to discover what children understand about these ailments. Further, despite arguing for the necessity of health education, research has failed to consider everyday aspects of health such as definitions of health and how children believe they can keep themselves healthy, key factors in any health education programme.

As discussed in Chapter 1, Piagetian theory has been criticised for underestimating children's abilities such as reasoning about physical phenomenon (Baillargeon, 1993). In line with these criticisms, taking this approach towards children's understanding of illness has also been criticised for underestimating how much children can understand. This research was mainly criticised for focusing on children's misconceptions and what they fail to understand rather than what they do understand. Furthermore, Hergenrather and Raboniwitz (1991) propose that it is incorrect to use Piaget's stages to plot the development of illness concepts in the first place. As Piaget's stages refer to children's logic and capability for certain types of thought, they argue that they cannot be used to plot their conceptual understanding. Carey (1985) also argues that specific concepts cannot be conceptualised as part of a domain-general Piagetian framework as children's reasoning skills are very different across domains. By this account, domain-general theories may not be appropriate for explaining theoretical development within a specific domain.

2.6.2. The Domain-specific Approach

With few exceptions, research in this area still fails to address many of the concerns raised regarding domain-general theories. In determining whether children have a naïve biology or not, research has mainly focused on contagion. Although this is useful to theoretical debates, it is not of practical importance when trying to determine what children know about illness. It fails to consider specific illnesses and does not add to knowledge on other types of ailment such as non-contagious illnesses and injuries (see also Williams & Binnie, 2002). Some studies do consider specific illnesses e.g. Sigelman et al. (1993) and Charman and Chandiramani (1995) but these studies are few and do not make a substantial contribution with the types of illness they investigate. This focus on contagion also means other important illness processes are neglected such as time course, recovery and prevention. Additionally, most studies have been concerned with preschoolers and have not considered further development of illness concepts throughout childhood. The few studies that have looked at further development suggest that conceptual changes occur but there is little agreement regarding the ages of these changes.

A further criticism is a lack of consensus among the researchers over what constitutes biological understanding. For example, Springer and Ruckel (1992) suggest that children have biological understanding based on their rejection of social explanations of illness. In contrast, Au and Romo (1999) look for a complete detailed explanation of germ action. Finally, there has not been a lot of work looking to translate these theories into educational practice and as a result there is a lack of practical application of this research. Despite the focus of the research being illness concepts, the findings have not yet been used to inform health care or practice. This is particularly important as the Piagetian stage model rejected by many active researchers still influences health practice. Domain-specific research has demonstrated practical value as educational programmes based upon this approach have been more effective than traditional approaches (Au, Romo & Dewitt, 1999; Sigelman et al., 1996). This will be discussed further in Chapter 3 and it will be a focus of this thesis to help rectify this criticism by looking to further the implications of domain-specific theories for education by examining the effectiveness of intervention approaches that are designed from this theoretical perspective.

2.6.3 The Health Psychology Approach

The main criticism of this approach is that it is based on experience and neglects factors internal to the child such as cognition. This approach stresses societal and other environmental factors but there is also a need to consider possible interactions between the environment and the individual child. Furthermore, this research is rarely based upon theory. Therefore, the questionnaires and interview schedules created to investigate illness concepts are driven by the researchers' own agendas. This also leads to studies being disjointed from each other rather than contributing to a body of research. Therefore, the impact of this research is frequently limited to specific single studies.

2.6.4. The Overall Picture

This chapter began by highlighting the disparate nature of the existing literature on children's understanding of illness. Here we return to this complaint. It is clear that a lot of effort has been placed on finding out what children understand about illness in order to fulfil the agendas of the different disciplines. Each approach has contributed something unique towards our knowledge of what children understand about illness. Firstly, the domain-general perspective was crucial in identifying that knowing about children's understanding of illness is important for health practice and education. The attempts that were made to plot the development of children's illness concepts may have underestimated children's understanding but were useful in identifying that these concepts became more sophisticated with age. Likewise, the domain-specific approach has discussed illness concepts from an intuitive biological perspective. This research helped to identify that children had more understanding than first thought and the use of child-friendly methodologies help to reveal this. Research from health psychology includes some interesting dimensions of children's health and illness not considered by cognitive developmental literature, such as the effect of experience, understanding of specific illness and beliefs about health and illness.

However, there is an incomplete picture of exactly what children understand about illness highlighting the need for further research. In particular there needs to be research that does the following: First, plots the development of illness concepts as the domain-general research has done. Second, acknowledges that development is more likely to be domain-specific and realises that illness is a biological concept. Finally, looks at a range of specific illnesses and illness processes in the way that health psychology has done.

Thus, this creates the rationale for the first empirical study of this thesis to be reported in Chapter 4.

2.7. Conclusions

The preceding review has discussed a large body of research on children's illness concepts from different theoretical approaches. The first conclusion reached from this review is that these approaches used in combination may provide a fuller picture of children's understanding of illness and they should not be seen as distinct approaches that contradict each other. The complementarity between research on what children believe, how they understand illness and the types of thinking that underlie their beliefs and knowledge should be evident. As described above, future work needs to utilise aspects of each these approaches in order to fully address the question of what children understand about illness.

The second conclusion drawn is that combining the findings from these approaches gives some idea of what children understand about health and illness and how this understanding develops. The three perspectives all agree on one thing: that children's illness concepts become more sophisticated with age. However, there are conflicting findings regarding how much children understand at different ages. For example, some research suggests that preschoolers know that germs are living things and that they cause illness (Kalish, 1996b) but other research suggests that they do not (Solomon & Cassimatis, 1999). Most theorists agree on some sort of conceptual change in understanding of illness at some point during childhood leading to a reorganisation of illness knowledge. However, there is little consensus on the age at which this change occurs or the state of children's understanding before and after. The most convincing findings report that children understand illness according to a physical model (Au & Romo, 1999; Kalish, 1999) and this progresses to a biological understanding in middle childhood. However, this attention on contagion means that not much is known of what children understand about non-contagious illnesses or injuries, or indeed illness processes other than contagion Therefore, future research is needed to plot the development of illness concepts, identify whether children have a physical or biological model of contagion and determine how they understand non-contagious illnesses and injuries. Before any interventions can be developed, it is necessary to conduct a separate investigation of children's illness concepts. The study to be reported in Chapter 4 will attempt to address these issues.

As well as cognitive development, Au and Romo (1999) argue that children may need educational instruction for their understanding of illness to correspond to formal scientific knowledge. Given the lack of studies which show that older age groups have formal understanding, it is likely that this is the case. It is beneficial for children to hold more formal theories of illness, health and health care as research has shown that these children have decreased anxiety and better health care (Vessey, 1996). However, as identified by this chapter, there is lack of up-to-date research that can inform educational practice in teaching children about illness. The domain-general approach still has a lot of influence but it has been argued in the previous chapter and this chapter that development proceeds in a domain-specific fashion. Therefore, it is likely that learning about illness involves more than just a domain-general enrichment of knowledge and the challenge for research is to identify intervention methods that can enhance children's understanding of illness through domain-specific processes of development. In an attempt to explore this issue, the proceeding chapter will discuss research that has looked at intervention methods to improve understanding of biology and will consider how domain-specific theories of development can help in developing successful methods of instruction.

Chapter 3:

Intervention Approaches to Improve Understanding of Biology

3.1. Introduction

As discussed in Chapter 2, studies which look at the development of illness concepts have found that older children have more sophisticated and coherent understanding of disease (Charman & Chandiramani, 1995; Hergenrather & Raboniwitz, 1991; Sigelman, Epstein & Carpenter, 1993). It has been suggested that educational intervention may be needed to achieve an understanding of illness that corresponds to formal knowledge (Kalish, 1999). Therefore, the challenge for research is to identify intervention methods that can help children reach this level of understanding. In general, methods which challenge or build upon children's intuitive knowledge of science are the more successful and Au, Romo and Dewitt (1999) have suggested that such approaches may help provide a coherent base for improving reasoning about health and illness. The aim of this chapter is to discuss possible intervention methods that could be effective in enhancing children's understanding of illness.

Frequently, the main barrier for children learning about science concepts is not a lack of knowledge but the knowledge that the student already holds (Driver et al., 1985). Often these "alternative conceptual frameworks" work well for children, as they explain phenomena and have a certain amount of predictive power, thus making children reluctant to replace them. As mentioned in Chapter 2, some studies have shown that preschool children hold naïve knowledge about illness (Kalish, 1996b; Raman & Gelman, 2004). This creates a problem for educators when trying to change these intuitive theories and concepts to match more formal understandings of science.

Educational researchers have traditionally described the replacement of older 'intuitive' theories with newer ones as conceptual change (Posner, Strike, Hewson & Gertzog, 1982; Vosniadou & Brewer, 1987). However, similar processes from the domain-specific literature also offer accounts of how children's understanding of scientific concepts develop. Chapter 1 includes discussion of the processes of RR (Karmiloff-Smith, 1992), conceptual change (Carey, 1985) and theory building (Gopnik & Meltzoff, 1997) and this chapter will include consideration of how these ideas can inform interventions.

As this thesis is concerned with looking at domain-specific approach to learning, this chapter will begin by discussing the potential direction of this research for practice, using health education as an example. It will then move on to discuss health education programmes that have demonstrated the successful enhancement of illness-related knowledge by basing interventions upon children's intuitive knowledge of biology. However, as these have mainly been full educational programmes, further consideration of specific types of instruction used to improve other aspects of biological knowledge will be discussed in this review. There are three main intervention types that have been explored for use with biology: direct experience, provision of factual information and collaborative learning. Studies from intuitive biological literature and education literature that have used these intervention methods will be included.

3.2. A New Approach to Teaching About Illness

As this thesis is primarily concerned with children's illness concepts, it is relevant to consider health education. Therefore, health education will be used in this section to show how the traditional health education approach could be improved through applying principles of domain-specific theories of cognitive development.

In general, it is presumed that health education as a whole has a positive influence on children as evidenced by major changes in health related behaviours over the last two decades (Tones & Tilford, 1994). However, two criticisms about health education in schools have been identified. Firstly, there is a widespread tendency to organise health education around major health topics making it unwieldy and sometimes unmanageable for children. An alternative would be to break down educational programmes into different more manageable components. Basing an intervention programme solely on illness concepts, for example, may not only lead to better understanding of the specific topic but it is also possible that learning about illness would generalise to other areas of health understanding.

Secondly, Au et al. (1999) argue that a new approach is needed towards health education. They state that current educators tend to focus on a long list of dos and don'ts and fail to explain the reasoning behind such instructions. In general, basing health education interventions upon theoretical models generally leads to greater understanding of the mechanisms and factors the intervention is trying to change.

Interventions with adults have been based upon thoroughly tested and validated models such as the Health Belief Model (Becker, Maiman, Kirscht, Haefner, Drachman & Taylor, 1979; Revere & Dunbar, 2001) and the Transtheoretical Stages of Change Model (Prochaska, Redding, Harlow, Rossi & Velicer, 1994) but there are no such proven models for use with children. Child health education interventions must take into account that children develop and so a model from Developmental psychology may be useful. Theunissen and Tates (2004) suggest Piagetian and Vygotskian influenced Cognitive Developmental models as a possibility. However, basing an educational intervention upon Piagetian or Vygotskian theory may not be the best way forward (see Chapters 1 and 2 for a critique of these theories). An alternative would be to base interventions on the suggestion that children's knowledge of the world develops in a domain-specific fashion and children construct theories about the world. To build on these intuitive theories may be the most valid approach to take towards improving illness concepts (Au et al., 1999).

3.3. Using Children's Intuitive Knowledge in Teaching About Illness

There are a series of studies that have designed health education programmes around the idea that children have intuitive knowledge or naïve theories of illness that can be built upon. These studies have mainly considered understanding of AIDS and HIV transmission (Au et al., 1999; Sigelman et al., 1996). Traditionally, it was argued that it would not be beneficial to provide young children with detailed information about AIDS as they were believed to be too cognitively immature to comprehend this information (Walsh & Bibace, 1990). However, Sigelman et al. (1996) argued that early education is important as it can help prepare children to avoid high risk behaviours, enable them to make better sense of the information, increase their compassion for people with AIDS and reassure them that they are not at high risk. Furthermore, extant research suggested that even brief HIV/AIDS education in schools can successfully increase knowledge of the disease (e.g. Ashworth, DuRant, Newman & Gaillard, 1992; Brown, Barone, Fritz, Cebollero & Nassau, 1991). From this viewpoint, age-appropriate intervention methods have the potential to be more successful than Walsh and Bibace (1990) suggest.

To investigate this fully, Sigelman et al. (1996) adopted a naïve theories approach in order to improve understanding of AIDS in 8 - 13 year olds. Children in this age group have been shown to hold misconceptions about HIV transmission, i.e. they commonly believe that HIV can be transmitted through the same behaviours that cause colds and that it can be caused by any form of drug use. The goal of AIDS education in this study was to achieve advances in both knowledge and understanding by exposing these flaws in children's naïve theories and offering them a more accurate alternative theory. Therefore, the curriculum was designed specifically to help children differentiate between AIDS and other diseases and reject their common misconceptions about HIV transmission. Various teaching methods were employed by this study including lecturing, class discussion and video clips. The findings showed that the programme led to improvements both in knowledge of key facts and causal reasoning of AIDS. This suggests that even relatively young children can grasp scientific theories of disease with the help of age-appropriate instruction, contrary to Piagetian suggestion.

Sigelman and her colleagues have explored the potential of this naïve theories approach through a series of studies examining the effect of similar educational programmes on teaching about drugs and their effect on the body. Firstly, their research determined that children with greater background knowledge of biology learned more about drugs and their effect on the body from instruction (Sigelman et al., 2003a). A further study compared different curricula for improving understanding of drugs (Sigelman et al., 2003b). Three versions of the experimental curriculum, a basic version, one with extra biological background information, and one challenging tobacco related misconceptions, were evaluated and compared to a control curriculum. Children in the experimental conditions showed increased awareness of the biological processes and scientific understanding that they were taught. The effects of the three experimental curricula did not differ significantly. This implies that the approaches of challenging misconceptions or providing a causally coherent theory of drug action work as well as each other.

Au et al. (1999) adopt a similar approach by suggesting building on children's intuitive theories of biology to help them develop an understanding of health and illness. Their target area of understanding was also, like Sigelman et al. (1996), AIDS and HIV transmission. Their approach to improving this understanding was systematic in that they first set about determining what children know in this area and how this understanding is linked. As outlined in Chapter 2, even young children may have sophisticated understanding of germs. To recap, pre-schoolers believe that germs are the causal agents of illness (Kalish, 1996b; Springer & Ruckel, 1992) and by age 6 children know that germs have biological attributes. However, although children understand that germs cause illness, they demonstrate very little understanding of how germs make people sick (Au & Romo, 1999). This leads Au et al. (1999) to believe that children know learned facts about illness without understanding any biological causal mechanism for how germs affect the body. This is important for the teaching about AIDS as one way to reason coherently and sensibly about AIDS is to rely on an understanding of a biological causal mechanism for HIV transmission.

Taking this into account, Au et al. (1999) designed a "Think Biology" curriculum that was designed to help 9 – 14 year old children fill this conceptual gap by explicitly teaching about a biological mechanism for HIV transmission. This curriculum comprised three lessons that focused on the biology of HIV. The children were taught that the AIDS virus is a living thing; it can reproduce, stay alive and die in various environments. Children already know some of these facts but this curriculum aimed to ensure that children were taught the crucial facts that the virus can stay alive and reproduce in a person's blood but it will die instantly in air and water. Knowledge of these facts allowed the children to reason about HIV transmission, for example, they would be able to figure out that you cannot get AIDS by sharing a swimming pool with someone who has AIDS. The "Think Biology" curriculum was compared to an existing AIDS education programme and it was found to be more successful at improving knowledge of AIDS. Children in the experimental condition appeared to think more coherently about HIV transmission and were better at reasoning about AIDS in novel situations. This "Think Biology" approach has been used in subsequent studies and has been found to improve understanding of STD transmission (Zamora, Romo, Bishop & Ulpindo, 2003), and colds (Au, Chan, Wan & Chan, 2005)

These studies highlight that an intuitive knowledge approach to health education can be effective at improving understanding of different aspects of health and illness. By building on what children already know or challenging misconceptions, appropriate intervention can improve knowledge and make understanding of illness more coherent and theory-like. However, these studies examine the efficacy of full educational curricula and programmes. These programmes comprise many different methods of instruction such as group discussion, guided lessons, watching videotapes etc. There is no way of indicating what parts of the curriculum used were most effective in improving understanding. Not only would it be beneficial to identify the most successful instruction methods but also it is important to identify the underlying learning mechanisms that are leading to the conceptual change. This could lead to the development of more efficient and effective intervention programmes.

3.4. Methods of Instruction

In order to determine what intervention methods would be effective at improving understanding of illness, the level and nature of children's intuitive knowledge of this area must be considered. Teaching children in areas where they already hold intuitive knowledge has been described as involving a process whereby they must incorporate or reconcile the formal knowledge with their intuitive/spontaneous knowledge. A framework to determine the best teaching methods is provided by Pines and West

(1986). They identify four possible interactions between formal and naïve knowledge: zero-spontaneous situation, spontaneous situation, congruent situation and conflict situation. The type of interaction that may occur when teaching children about biology depends on the nature of children's intuitive biological knowledge. The zero-spontaneous situation can be discounted as Chapter 1 and Chapter 2 have described a large body of evidence stating that children have intuitive knowledge of biology before being taught in school. However, it is not obvious which of the other three categories is most appropriate for biological knowledge and this has implications for the most appropriate teaching method to be used.

In the spontaneous situation, there is no formal school knowledge presented yet the child's spontaneous knowledge is extensive. Therefore, experience of biology gained through individual investigation should be enough to promote understanding that corresponds to formal knowledge. Would it be possible to design an intervention method that gives children experience with a biological phenomenon and leads to increases in knowledge? The first sub-section will attempt to answer this question but it will become clear that illness is difficult to manipulate so this will not be considered in the rest of this thesis.

Alternatively, the formal and naïve knowledge may be congruent with each other. Pines and West (1986) argue that biological knowledge often falls into this category of knowledge interactions and some of the research covered in Chapter 2 would suggest that children have intuitive knowledge of illness that may form a basis for more formal knowledge. A process of cognitive change is required to incorporate the new knowledge and adapt existing naïve knowledge. One possible method of instruction would be to provide children with the age-appropriate facts that they lack from their intuitive knowledge. The second sub-section will consider the effectiveness of factual information as an intervention method.

At the other extreme, there are cases where naïve and formal knowledge directly contradict each other. In these circumstances encouraging the learning of the formal concepts can be difficult because the child's naïve knowledge can act as a barrier to learning (Driver et al., 1985). Pines and West (1986) argue that many areas of physics concepts fall into this category and learning through a process of cognitive conflict whereby children become aware of their misconceptions, question them and later reformulate their concepts, is often successful. However, children find certain areas of biology conceptually difficult to grasp, indicating that naive concepts of biology may not be congruent with formal knowledge. These include genetics (Thomas, 2000; Williams and Affleck, 1999; Williams & Tolmie, 2000), photosynthesis (Anderson, Sheldon & Dubay, 1990) and some illness processes (Au & Romo, 1999). In these instances an intervention that is designed to engender cognitive conflict is often required to facilitate learning. The most successful method for this has been found to be collaborative learning (Howe, Rodgers & Tolmie, 1990) and this is covered in the third sub-section.

By this account, there are three main intervention approaches that can be investigated for use with biological knowledge. These are direct experience, factual information and collaborative learning. The following sections will cover each of these in turn and discuss, where appropriate, the theoretical background, empirical findings and the possible mechanisms underlying learning. These sections will not just scrutinize research on illness and health but also biology as a whole. This is because there is not a substantial literature on illness so other dimensions of biological understanding need to be considered to provide a fuller picture. For the same reason, research on improving understanding of physics is also included.

3.4.1. Direct Experience

If children hold spontaneous knowledge of biology without receiving formal teaching, then providing children with direct experience of biological phenomena should be enough to enhance knowledge (Pines & West, 1986). Kellert (2002) distinguishes between types of experience children have with nature and how this can influence development. Specifically, he identifies direct experience, e.g. play in natural settings giving direct experience of plants and animals; indirect experience, e.g. physical contact with nature in more managed contexts such as zoos or pet ownership; and symbolic experience, e.g. television, films and books. Evidence has shown that these types of experience can have a positive impact on cognitive development (Kahn, 1999; Kellert 1996; Kellert & Vollbracht, 2000).

There is also research, although it is limited, looking specifically at the development of biology concepts. Chapter 1 mentioned that direct experience was one of the key factors in Inagaki and Hatano's (2002) ideas about influences on the development of children's biological thought. Inagaki (1990) provides empirical evidence for this by demonstrating the positive influence of pet ownership. She investigated the effects that raising a goldfish had on children's biological knowledge of animals by matching 5 year old children who had previously raised a goldfish for 3 months or more with children who had never raised any animal. Through individual interviews it was found that the goldfish raisers not only displayed a greater amount of factual knowledge but also more conceptual knowledge. Conceptual knowledge was measured by children's responses to questions that asked how goldfish would respond in novel situations and their explanations about the meaning of goldfish raising. In addition the goldfish raisers could relate their knowledge of goldfish to similar aquatic animals, such as a frog, to make reasonable predictions about a frog's life.

Likewise, Williams and Smith (in press) have found that children who own a pet show slight advantages in knowledge of inheritance than those who do not. They also report that children in rural areas have greater understanding than those in urban areas. This is accounted for in terms of rural children's increased direct experience with animals and fauna. Additionally, research has noted the educational benefits associated with increased experience of animals through visiting zoos (Altman, 1998; Chouinard, 2003; Tunnicliffe, Lucas & Osbourne, 1997).

Despite these positive findings regarding the effect of experience, it would be impossible to manipulate experience of illness. At any rate, findings from studies that compare children with experience of an illness to children with no experience have been mixed. For example, Rubovits and Siegal (1994) found that children with diabetes have more sophisticated concepts of disease management than a group with no experience of diabetes. In contrast, Perrin, Sayer and Willett (1991) report that children with an orthopaedic condition showed less sophisticated concepts of illness than a control. Results such as this are argued to be due to the chronic condition interfering with general cognitive development that in turn affects illness concepts. Research on more common childhood illnesses, namely chicken pox and asthma, which are not likely to affect cognition development has found that knowledge is higher in children who have first hand experiences of these illnesses (Myant & Howe, 2003). Taking this into consideration, direct experience may improve understanding of some aspects of biology but it is not clear that it improves understanding of illness and it is certainly not a practical intervention method for use with this concept.

3.4.2. Factual Information

The second type of intervention method involves the provision of factual information. If illness is an area of knowledge where formal and naïve knowledge are congruent, interventions that provide illness facts in child-appropriate language should enhance understanding through a process of cognitive change (Pines & West, 1986).

There are further theoretical grounds why factual information may be effective in enhancing children's learning of biology. Two propositions about the importance of factual information were introduced in Chapter 1. Springer (1999) argues that "the critical factor driving the acquisition of naïve biology may be the acquisition of factual knowledge, combined with certain key inferences generated from this knowledge" (p.46). He suggests that by the age of 4 to 5 a naïve theory of biology is autonomous but that growth in this domain is heavily influenced by children learning facts about the biological world. A second influential theory about the development of biology knowledge has been proposed by Inagaki and Hatano (2002). They argue that children learn about the biological world by employing "constrained personification" whereby they use their knowledge of humans to make inferences about biological processes in other animals and plants. Two constraints are believed to influence this process of personification, one is the "similarity constraint" where the more similar a target is to humans the more likely personification will be employed. Another constraint is the factual check or "feasibility constraint". From this viewpoint, even young children have extensive knowledge about living things and their factual knowledge database is extremely important in checking the plausibility of personification. Thus, great importance is placed by Inagaki and Hatano on the role of factual information in children's learning of biology.

Springer (1995) was interested in the origin and acquisition of a naïve theory of kinship and argued that teaching facts of intrauterine development and birth to young children should help lead to the acquisition of a naïve theory of kinship. As mentioned in Chapter 1, this naïve theory of kinship consists of three beliefs: firstly, that children presume babies share more physical properties with their mothers than with unrelated animals (Springer, 1992), secondly, that children consider good and bad functional properties to be equally heritable and thirdly, that children believe inheritance occurs by material transfer from mother to child. These beliefs, he argued, are deduced from children's knowledge of certain simple facts about inheritance and kinship. He reported these as being that babies grow inside their mothers, that foetal growth is not normally affected from influences outside the womb and that physical proximity facilitates the transmission of physical properties. Springer's (1995) findings showed that if children held knowledge of these basic facts they can begin to draw appropriate inferences about inheritance processes. He further reported the results of a training study where children who did not have knowledge of these facts about prenatal development were taught the basic facts without being taught about detailed biological inheritance processes. Children in the training condition showed significantly improved knowledge and understanding at post-test, implying that teaching children simple biological facts can improve theoretical knowledge of inheritance.

However, Williams and Affleck (1999) attempted to replicate Springer's findings and found that factual information did not improve understanding of inheritance in their sample of 4 and 7 year olds. They suggest that one possible reason for this discrepancy may be due to the materials used. Williams and Affleck's (1999) materials contained reference to animals rather than humans, in an attempt to prevent children relying on their concrete knowledge of humans and provoke intuitive thinking. However, a more likely reason, they argue, is that the lack of effect of the intervention was due to the high levels of baseline knowledge observed at pre-test in their sample. As a result, the factual information provided did not build on their intuitive knowledge, as they already knew most of the facts. This indicates the importance of determining children's baseline knowledge before designing an intervention.

One further possibility for the failure of this study is the probable lack of engagement that children would have had with the task materials. Both Springer and Williams and Affleck read stories out to the children with no real effort to promote engagement with the materials. Promoting engagement is important for making the learning tasks seem 'real' and relevant to the children (Newmann, 1991) which in turn leads to interest among the children and high motivation to learn about the topic. More of an effort to involve the children in some way with the facts may lead to more convincing effects. A related issue that needs flagged up is that children's understanding of biology may not, as suggested by Pines and West, be congruent with formal knowledge. If this is indeed the case (this will be investigated by the study reported in Chapter 4 and discussion will therefore be devoted to this in Chapter 5) then this makes the case for promoting engagement with factual information even more crucial as efforts to overcome conflicting ideas of biology will need to be made.

Throughout the literature recounted here, factual information is normally used to refer to basic facts of biology. An alternative to providing children with these basic facts would be to provide them with explanations, slightly different from basic facts as they give an account of processes above and beyond basic detail. Distinguishing between basic facts and explanations would allow a closer examination of how providing children with factual information leads to increases in knowledge.

Added to this, it would be beneficial to have some idea of *how* providing facts or explanations might lead to conceptual change. It is possible to speculate on some candidates here. The most basic model would suppose that children's knowledge is enriched through the provision of basic facts. This would also suggest that children's knowledge is further improved if explanations are provided. Another account would favour theory building (Carey, 1985; Gopnik & Meltzoff, 1997; Wellman & Gelman, 1992) where basic facts or explanations would serve to contradict and reaffirm aspects of children's theories engaging a process of theory revision and conceptual change. Alternatively, it could be through RR (Karmiloff-Smith, 1992), where children's representations are restructured from an implicit non-verbalised understanding (i.e. I level representations) to a more theoretical understanding open to explicit verbalisation (i.e. E3 Level representations). This explanation has been used to explain the findings of other intervention studies (Pine & Messer, 1998) that provide children with detailed explanations.

In sum, most studies have shown that the provision of factual information is successful in enhancing understanding of biology. Unfortunately, there is a lack of studies in developmental psychology that have investigated the efficacy of factual information to improve knowledge of illness. Springer (1995) has shown that basic facts can increase theoretical understanding of inheritance but Williams and Affleck (1999) attempted to replicate this study and found factual information to be an ineffective intervention method. However, further research is needed to determine the level of factual information that is more appropriate; in particular there is a lack of research that considers the effect of providing children with explanations. One fruitful avenue of research would be to investigate the best ways in which to promote engagement with factual information materials. Furthermore, if factual information does lead to increases in knowledge, what are the processes that underlie this? It may be some form of conceptual change or it could be rote learning leading to enrichment of knowledge. This is another question which future research could aim to answer.

3.4.3. Collaborative Learning

As discussed, children's intuitive knowledge of science can sometimes be in direct conflict with formal knowledge. Pines and West (1986) suggested physics understanding as such an area of knowledge but some areas of biology are also difficult for children to grasp. In general, intervention methods that promote cognitive conflict are needed to lead to conceptual change in such instances. The most successful method investigated to date is collaborative learning.

Much research has found collaborative learning to be beneficial for individual cognitive gain (Doise & Mugny, 1984; Rogoff, 1990). This research has been informed by the theories of Piaget (1932) and Vygotsky (1978). Although Piaget's theory mainly focused on the individual aspects in cognitive development, he recognised the potential productivity of peer interaction in relation to cognitive development (Piaget, 1926, 1932). Piaget described the process that drives subsequent individual performance through collaborating with other children as "socio-cognitive conflict", i.e. arguing or debating with peers with conflicting viewpoints lead to cognitive disequilibration, and the process of re-equilibration resolves the conflicting elements and leads to conceptual growth. He further observed that children are most challenged in their thinking when they are with peers rather than adults, because they all are on an equal footing and are more free to confront ideas. There is also no appeal to status to determine which is right. However, when children are too similar in their thinking, there may be little to debate about, resulting in fewer developmental gains. This indicates the importance of the social dimension of the situation, it is not as simple as placing children together who are at different cognitive levels – they must enter the situation with different cognitive perspectives. Subsequently, investigation of how social interaction affects individual cognitive development has been undertaken and it is generally accepted that peer interaction shows superior performances at individual post-test than individual training (for a review see Doise & Mugny, 1984).

Vygotsky's (1962, 1978) socio-cultural approach has also influenced research on collaborative learning (Wertsch, 1979, 1991; Rogoff, 1990). This differs from the Piagetian approach as instead of championing socio-cognitive conflict as the mechanism facilitating cognitive development, Vygotsky argues that the communication between individuals is more important. These communications, or "inter-psychological processes" are the internalised by the individuals involved and become "intra-psychological", in other words, inner speech. By this account, each learner stores the conversations conducted during the collaborative problem solving and later reflects on elements of the dialogue.

Vygotsky differs from Piaget by asserting that collaboration with more skilled partners, as opposed to those at a similar developmental stage, is important. Vygotsky explains that the more experienced partner provides help in the way of an intellectual scaffold, which allows the less experienced learner to accomplish more complex tasks than may be possible alone. This is defined as the "zone of proximal development", more specifically, "...the distance between the actual developmental level as determined by independent problem solving and the level of potential development as determined through problem solving under adult guidance or in collaboration with more capable peers" (Vygotsky, 1978, p.86).

From these theoretical contentions, a wide body of research on collaborative learning has arisen. Considerable research effort has been directed towards this and many issues have been investigated. These include the types of knowledge or skills that collaborative learning can influence positively, the most productive make-up of the groups, and the underlying processes that are responsible for such dramatic increases in knowledge. However, a major direction for research on collaborative learning has been to consider how children working together can enhance conceptual change.

Group discussions have been used as a mechanism for promoting conceptual change in the domain of physics by Howe and colleagues. A series of studies on naïve physics showed that letting groups of primary school children discuss phenomena such as sinking and floating (Howe et al., 1990; Tolmie, Howe, Mackenzie and Greer, 1993), motion down an incline (Howe, Tolmie & Rodgers, 1992) and heat transfer (Howe, Tolmie, Greer and Mackenzie, 1995) led to increases in knowledge and understanding.

To give one illustration of this work, the study by Howe et al. (1995) put together groups consisting of four children aged 8 to 12 years and let them discuss characteristics of heating and cooling. In this study, pre- to post-test change was greater when there was a larger degree of collective understanding displayed during the group task. However, that collective insights induce learning was not a consistent finding from other studies. For example, Howe et al., (1990, 1992) found that the greatest advancements occurred when members of the group held different conceptions as predicted by theories which state that cognitive conflict can promote conceptual change through forcing a reassessment of conceptualisations (Piaget, 1932; Doise, 1990). When a child's views are challenged by another child who holds an alternative perspective, they are forced to compare their differing viewpoints and rethink their own original beliefs (Doise & Mugny, 1984). This is backed up by the finding that the amount of conceptual change observed in these studies was related to the amount of disagreement and conflict within the group rather than the agreements within the group (Howe et al., 1992; Tolmie et al., 1993). As cognitive conflict experienced by a child working individually was not found to lead to such conceptual advancement, it is implied that group discussions promote conceptual change through a successful process of socially generated cognitive conflict (Tolmie et al., 1993).

The conceptual increases observed in these studies were often not apparent immediately. Greater conceptual advancements were observed when a delayed post test was administered compared to an immediate post-test. For example, Howe et al. (1992) administered immediate post-tests and post-tests at 6 weeks. It was found that there was a greater increase in knowledge and understanding at the delayed post-test. This increase in knowledge has also been observed between post-tests at 4 and 11 weeks (Tolmie et al., 1993). One explanation is that the group discussions act to create conflicts that are later resolved rather than creating solutions to be remembered. However, recent research by Howe, McWilliam and Cross (2004) suggests that this "delayed post-test effect" is due to external input experienced after the group tasks. The discussions are believed to prime the children to pay more attention to references to appropriate material. Therefore, the greater the delay, the more time the children have to pick-up relevant information.

Various researchers have now investigated whether similar discursive interactions induce conceptual change in biology. There are a few instances in the science education literature. For example, Lumpe and Stave (1995) showed that high school students working in groups developed more scientifically correct conceptions of photosynthesis than students working alone. Additionally, Ponce and Schneeberger (2002) found that interactions among children promoted the acquisition of knowledge in biology, particularly if there was conflict of ideas within the groups.

Chapter 1 described Inagaki and Hatano's (2002) proposition that "sociocultural constraints" are influential in the development of children's biological thought. They assert that a child's social context is crucial for building upon naïve biological knowledge to acquire an advanced knowledge system. They base these claims upon empirical findings. Hatano and Inagaki (1997) attempted to show that if children engage in collaborative activities, they are likely to acquire an advanced biological knowledge system more readily. They compared a control group who received basic facts about evolution with an experimental group who received the same facts and participated in a whole class discussion. Results revealed that the children in the experimental group gave significantly more elaborate explanations than the children in the control subjects. From this they conclude that it was the joint attempt at comprehension by the group that led to the acquisition of more sophisticated knowledge than the individuals working alone.

A more systematic evaluation of the impact of collaborative learning on biology concepts was undertaken by Williams and Tolmie (2000). They examined understanding of inheritance in 8 - 12 year olds and evaluated the impact of a variety of intervention approaches. Three different experimental intervention conditions were compared: individual condition aimed to generate cognitive conflict; group condition with children who had similar naïve concepts; and a group condition with children who had differing naïve concepts of inheritance. Group discussions involving children with differing conceptions of inheritance were found to be the most successful. Dialogue analysis of the group sessions revealed that learning proceeded through a process of co-ordination of ideas rather than thorough explicit conflict as has been found in relation to physics (Howe at al, 1990). Williams and Tolmie (2000) argue that this difference observed in the group processes may be due to the nature of children's inheritance concepts. Howe et al. (1995) identified that there are clear signs of differences between topic areas in physics in the degree of underlying structure of children's concepts, and that this has considerable impact on the nature of children's discussions. As it has been suggested that children's biological ideas are more congruent with formal science than physics ideas (Hatano, 1990; Pines & West, 1986), then they may be able to co-ordinate ideas more easily without the same degree of conflict/task support.

Collaborative learning has also been used in research to improve children's concepts of illness. For instance, Williams and Binnie (2002) showed group discussion leading to slight improvements in understanding of illness. Children aged 4 and 7 years were placed into groups of five and discussed issues relating to three common ailments, chicken pox (contagious), asthma (non-contagious) and a scraped knee (injury). When compared to a control group which received no intervention, the mean pre-test to post-test change was greater for the intervention group. This is a promising finding showing that collaborative learning may be a possible way of learning about illness. However, the groups of children in the experimental condition were given basic factual information in the form of short stories before the discussions. Therefore, it is not clear whether the improved knowledge is due to this factual information or the discussions. This needs to be unpacked to determine if the factual information alone or the group discussions alone would have a similar effect.

One further project investigated the efficacy of different intervention methods based on the provision of factual information and collaborative learning for improving understanding of illness (Myant & Howe, 2003). The target areas of understanding included in this study were chicken pox and asthma. A control group was compared with three experimental conditions: factual information, factual information followed by group discussion, group discussion followed by factual information. Findings indicate there was no difference between intervention conditions and the control group in understanding of asthma. However, the factual information condition and the group discussion followed by factual information condition both showed significantly greater pre- to post-test change than the control for understanding of chicken pox. The finding that providing factual information is an effective way of improving biological knowledge is in line with Springer (1995). The most surprising finding was that factual information followed by group discussion was not successful in improving knowledge. This implies that when the factual information is given to the child is a crucial point. Giving the children the facts after they have discussed the topic is more successful. This relates back to Howe et al.'s (2004) proposal that children are more primed to pay attention to relevant material after they have discussed it. However, a caveat in this study is that the pre- and post-test in this study did not include a measure of reasoning about novel situations or generalisability. It only measured increases in knowledge measured by the number of correct symptoms, processes and treatments mentioned. Therefore, more research is needed to consider collaborative learning on its own and to measure theoretical understanding.

In sum, collaborative learning is a well recognised instruction method for use in the teaching of science (Kutnick & Blatchford, 1999). It has been shown to promote marked increases in understanding of physics (Howe et al., 1992) and this is argued to be due to the conflict experienced in the groups. Similar increases in knowledge have been observed in children's understanding of biology but the processes involved may be slightly different due to the nature of intuitive biological understanding. Initial research investigating group discussions as interventions for illness concepts is promising. However, existing studies have combined group discussion with factual information so it is not clear which has the most benefit or if combining factual information with group discussion is the best approach.

3.5. Conclusions

This review has covered a breadth of literature from different disciplines in an attempt to identify possible instruction methods for improving understanding of illness. Several conclusions can be reached as a result of this review. A possible new approach towards health education has been identified by researchers. Educational programmes to teach about health have been based on the idea that development proceeds in a domain-specific way and that children possess intuitive knowledge of the world. Specifically, two ideas for developing educational intervention methods have emerged: educators can build on what children already know or produce materials that challenge their misconceptions and replace them with formal knowledge. So far though, there are only a few studies in this area.

Secondly, discussion has focused on the types of intervention methods that have been used to improve children's biological understanding. In particular, it seems as though collaborative learning and the provision of factual information may be productive methods of instruction with the further option of combining these. However, there is a distinct lack of research on improving children's understanding of illness which needs to be addressed.

Finally, there are two main types of research that investigate methods of instruction for promoting conceptual change. The first of these administers educational interventions and looks for a measure of how successful they are (e.g. Au et al., 1999; Sigelman et al., 1996). For the second type of research, it does not matter so much whether the intervention has been successful or not, what matters is the underlying processes of why the approach succeeded or failed (e.g. Howe et al., 1995). What appears to have happened is that there is a split between theory and practice-based researchers. Co-operation between these two camps or at least a consideration of both theory and practice is needed in future research to develop the most effective intervention methods.

The foregoing chapter shows clearly that there is scope for further research into methods of instruction to enhance conceptual change in this area. The issues raised by the present chapter will be taken into account in designing intervention methods based on collaborative learning and factual information. In particular, it is acknowledged that an approach which recognises children's intuitive knowledge about illness is needed. Chapter 2 showed that there are many gaps in our knowledge concerning what children understand about illness. Therefore, the first empirical study of this thesis will aim to fill these gaps and will show the areas of knowledge that would benefit most from intervention. This is reported in the following chapter. Thereafter, the following two empirical studies will systematically investigate the ideas raised in this chapter by conducting studies looking at the efficacy of factual information and collaborative learning as intervention methods to teach about illness.

Chapter 4:

Study 1: Children's Understanding of Contagious Illnesses, Non-contagious Illnesses and Injuries[1]

[1] A version of this chapter has been published in the Journal of Health Psychology. The published article can be found in Appendix VI.

4.1. Introduction

The study reported in this chapter investigates the development of children's understanding of illness and health. This study is an important part of this thesis for two reasons. First, this study aims to provide a more complete picture of children's understanding of illness. As identified in Chapter 2, there are several gaps in the literature on children's understanding of illness and a more comprehensive approach is needed. It is expected that the findings of this study will add to debate concerning intuitive biology as well as adding to health psychology literature on understanding of specific illnesses.

Secondly, the results will provide the basis for the intervention studies to be reported in Chapters 5 and 6 by providing a reliable baseline measure of children's understanding of illness and identifying possible age groups and areas of illness understanding that would benefit from intervention. As identified by Au, et al. (1999), it is important to determine exactly what children know about illness and what the gaps in their knowledge are before designing an intervention programme. Otherwise, there is a risk of teaching children what they already know as demonstrated by Williams and Affleck (1999) (see Chapter 3) or assuming they understand more than they do.

In order to fully address previous criticisms as set out in Chapter 2 and provide a reliable baseline for the intervention studies, there are four major issues that must be first considered. First, there is the question of what illnesses to include. One criticism of the developmental approach to children's understanding of illness is that it frequently does not consider specific illnesses and neglects non-contagious illnesses and injuries. In contrast the health psychology approach is focused on understanding of specific illnesses, but these are usually chronic conditions. To strike a balance between these approaches, this study will include common childhood illnesses that children are likely to have some experience of. In line with Williams and Binnie (2002), contagious illnesses, non-contagious illnesses and injuries will be included. This will allow an examination to see if different types of illness are understood in different ways. Additionally, children will be asked for their definitions of illness and health.

Secondly, previous research has been criticised for focusing too strongly on causality of illness (e.g. Siegal, 1988; Solomon & Cassimatis, 1999). In terms of biology, this is the most important process as it shows whether children understanding the biological mechanism of contagion (Au & Romo, 1999; Kalish, 1999). However, little research has been conducted on children's understanding of the prevention, time course or recovery of illness. This study will include a range of illness processes which will show how an understanding of illness extends beyond causality. Furthermore, an analysis of the full range of illness processes will be useful in determining if children's understanding of illness is causally linked and therefore theoretical.

A third issue concerns the age range of children that needs to be investigated. As discussed in Chapter 2, there is some agreement between Piaget's stage model and the development of children's illness concepts (Bibace & Walsh, 1981). Although the domain-general approach to children's understanding of illness underestimated what children are capable of understanding of illness, it was useful in showing that the development of illness concepts continues throughout childhood. The domain-specific approach has not followed this trend and usually only looks at preschoolers. This means that development of illness concepts throughout childhood has not been investigated by these researchers. Therefore, this study will include children up to the age of 11 years in an attempt to plot the development of children's understanding of illness and determine at what age it becomes "biological".

Finally, different research studies have used many varied methodologies and it is clear that the methodology used can have significant impact on the results. Traditionally, it is argued that open-ended questioning methods in illness research do not allow children to display their full understanding whereas forced choice methodologies have been shown to credit children with more understanding. However, a drawback with forced choice methods is that they do not reveal anything about the detail or accuracy of children's explanations of illness. For these reasons, an open-ended questioning method was chosen for this study as it allows children to express their spontaneous thoughts and may indeed be the only appropriate method for probing some issues (Howe, 1998). Although it was noted that the full extent of understanding among the youngest children may not be tapped by this type of method (Smith & Williams, 2004), it was hoped a more compete picture of understanding of illness will be obtained than by using forced choice methods.

4.2. The Present Study

The present study aimed to consider general definitions of the concepts of health and illness as well as understanding of specific illnesses. The age range in this study was extended to include children from 4 years up to 12 years allowing an examination of the development of illness concepts throughout primary school. It was predicted that concepts become more sophisticated and accurate with age. The specific illnesses were common childhood ailments that the children have some knowledge of as shown by previous research. In addition, more than just understanding of causality was investigated with questions on definitions, prevention, time course and recovery also being asked. It was thought likely that the children will have different levels of understanding of the different illnesses. It was expected that the results will hold strong implications for the development of intervention programmes designed to improve knowledge of illness.

4.3. Method

4.3.1. Participants

A total of 83 children participated in this study from state-run primary schools and both state-run and private nurseries in Glasgow. The sample comprised four age groups: four year olds (N = 20, 9 boys, 11 girls: Mean age = 4,7; range = 4,0 to 5,3); seven year olds (N = 20, 10 boys, 10 girls: M = 7,9; range = 7,4 to 8,2), nine year olds (N = 21, 13 boys, 8 girls: M = 9,9; range = 9,4 to 10,3) and eleven year olds (N = 22, 12 boys, 10 girls: M = 11,9; range = 11,4 to 12,4).

The sample was recruited through a process of Education Authority approval and school willingness to participate. Parents in the relevant age groups were then invited to give their permission for their children to participate in the study and were informed of the purpose of the study and the importance of the findings for health education and cognitive development research. They were also advised that all data would remain confidential and anonymous. Therefore, written parental permission was received for all participants. Some participants (N=5) did not have English as their first language and although they were interviewed in line with inclusive practice they were not included in this final analysis.

Social background

Free school meal entitlement figures were used to classify each school as belonging to either a low, mid or high socio-economic status group (SES). These figures are frequently used as an indicator of social deprivation (Scottish Executive, 2003). The children were split fairly evenly across three schools. One of these was classed as mid-SES, the other two as low SES. This data are not available at nursery level although it is predicted that two of the nurseries would have been classed as mid SES and two as low SES.

4.3.2. Pilot Study

Initial items were extensively piloted on a sample of 45 children. Nine common ailments were asked about but this was reduced to six as the interview was felt to be too long. The nine ailments consisted of contagious illnesses (cold, chicken pox, tonsillitis), non-contagious illnesses (asthma, toothache, eczema), and injuries (broken leg, sprained wrist, bruised knee). One ailment in each category was taken out. These were tonsillitis, eczema, and sprained wrist. In addition, prompting for each question was introduced as a result of the pilot study's findings. Children would be asked for explanations of their responses (e.g. why would that make someone ill?) as this would yield more insights into the children's knowledge (Springer & Ruckel, 1992). The final materials and procedure used are described below.

4.3.3. Materials

Introductory questions

Two questions asking for general definitions of health and illness were drawn up (Can you tell me what it means to be ill/healthy?). These questions served a dual function: firstly, they eased the participants into the interview situation and secondly, they allowed an examination of understanding of the concepts of health and illness in general.

Vignettes

Six short vignettes were written describing child characters with different illnesses. The ailments described were: contagious illnesses (cold and chicken pox), non-contagious illnesses (asthma and toothache), and injuries (bruise and broken leg). Each vignette described the symptoms experienced by the character and gave the name of the illness. The vignettes were of the same form and complexity for each illness and described the same number of symptoms. In addition, to maintain the participant's interest, a cartoon drawing of each of the characters accompanied the vignettes. This method of employing vignettes facilitate children's ability to answer questions concerning their representations has been used widely in research on illness (e.g. Kalish, 1996a, 1996b, 1997; Siegal, 1988; Solomon & Cassimatis, 1999; Williams & Binnie, 2002) and children's understanding of biology more generally (e.g. Smith & Williams, 2004; Williams & Tolmie, 2000). In this study, questions about each illness which followed the vignettes explored different dimensions of the illnesses. The questioning began by asking for a definition of the illness, a simple question designed to be easy for the child to answer. This helped establish a focus on each ailment and build up a rapport between researcher and child.

For example:

"This is Johnny. Johnny has a runny nose and a sore throat. He also coughs and sneezes a lot. This is because Johnny has a cold."

Definition: What is a cold like?

Causality: How do you think Johnny got a cold?/ Why would that make Johnny get a cold?

Prevention: What could Johnny do to stop himself from getting a cold?/Why would that stop Johnny from getting a cold?

Time course incubation: How long would it take for Johnny to feel bad?/Why would it take that long for Johnny to feel bad?

Recovery: What could Johnny do to make himself feel better?/Why would that make Johnny feel better?

Time course recovery: How long would it take for Johnny to feel better?/Why would it take that long for Johnny to feel bad?

The full interview schedules along with the cartoon drawings are included in Appendix I.

4.3.4. Procedure

The participants were individually interviewed in a quiet room separate from their classroom. They were told they were going to be asked some questions about different illnesses, that there were no right or wrong answers and that they were free to leave the interview situation at any point. The introductory questions were asked first followed by the vignettes and questions for the specific illnesses. First the vignette was read out to the participant and they were shown the cartoon drawing. The questions about each illness were then asked. These always followed the same order. However, the order in which each of the illnesses was presented was randomised for each participant. Probing was used to elicit full answers from the participants. Children were asked to fully explain their answers until it appeared that they had revealed the full extent of their understanding. The interviews were tape recorded and transcribed before analysis.

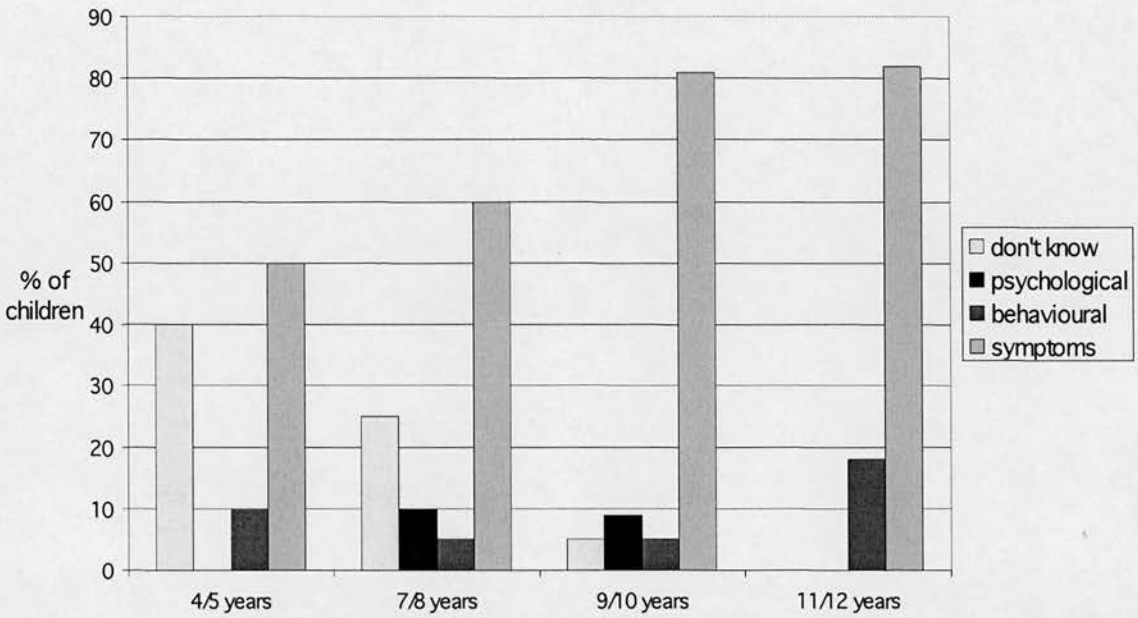
4.3.5. Coding

The data was coded using content analysis (see Krippendorff, 1980; Weber, 1995), a method frequently employed for analysing children's explanations of illness (Perrin, Sayer & Willett, 1991; Raman & Winer, 2002; Sigelman, Maddock, Epstein & Carpenter; 1993). Two coders used 15% of the response scripts to devise appropriate categories. After discussion the final categories were decided and used to analyse the remaining response scripts by the two coders. The final categories were fairly broad in order to encompass responses to each of the illnesses/injuries. Although this may lead to missing some detail of the data which would remain with narrow categories it does have the advantage of allowing analysis of cross-illness comparisons. Since one of the purposes of this study was to look at cross-illness variations in representations it was crucial to devise a coding scheme that would allow statistical comparisons across the illnesses. Full details of the coding system are given in Appendix II. For the definitions of illness and health and the strategies for recovery, it can be seen that the data were coded into separate categories independent of each other. For definitions, causality and prevention a higher score indicated a higher level of response. An attempt was made to maintain a high level of detail with the coding of the causality questions by including an accuracy measure. This enabled responses to be coded in two ways: firstly, whether they were biological or physical and secondly, how accurately they described the mechanism. The time course items were also coded according to how accurate they were.

4.4. Results

The data for each question were analysed using either chi-square or two-way ANOVAs with follow-up tests. Where data were judged to be categorical and therefore non-parametric as in the case of definition of illness/health and strategies for recovery from illness, chi-square analyses were employed to explore age trends (in line with Charman and Chandiramani, 1995). However, for some of the questions each response type superseded the other in level of sophistication and therefore a higher score indicated a greater level of understanding. This means the data were ordinal. However, it was decided to use parametric testing for these items as this form of testing offers more power and allows analysis of important age by illness type interactions. Such analysis on data like this has been frequently utilised in previous research (e.g. Springer & Keil, 1991; Williams & Binnie, 2002; Williams & Tolmie, 2000). Thus, for questions on definition, causality, prevention and time course the data were analysed parametrically using age group (4 years, 7 years, 9 years, 11 years) x illness type (cold, chicken pox, asthma, toothache, bruise, broken leg) two-way ANOVAs. Any main effects were then examined by use of post hoc t-tests with corrections for the significance values or post hoc Tukey's HSD procedure. Interaction effects were explored with the use of one-way ANOVAs and post hoc Tukey's HSD. Effect sizes reported are Cohen's d for t-tests and Cohen's f for ANOVAs (Cohen, 1988).

Figure 4.1: Percentage of children giving each type of definition for illness



In relation to definitions of illness, Figure 4.1 shows the percentage of children giving each response type. "Don't know" answers decrease across the age groups and "symptom" answers increase with age. Behavioural and psychological definitions are generally unpopular with all age groups. A chi-square test (χ^2 = 21.65, p < .01) indicated the response pattern is associated with age.

Figure 4.2: Percentage of children giving each type of definition for health

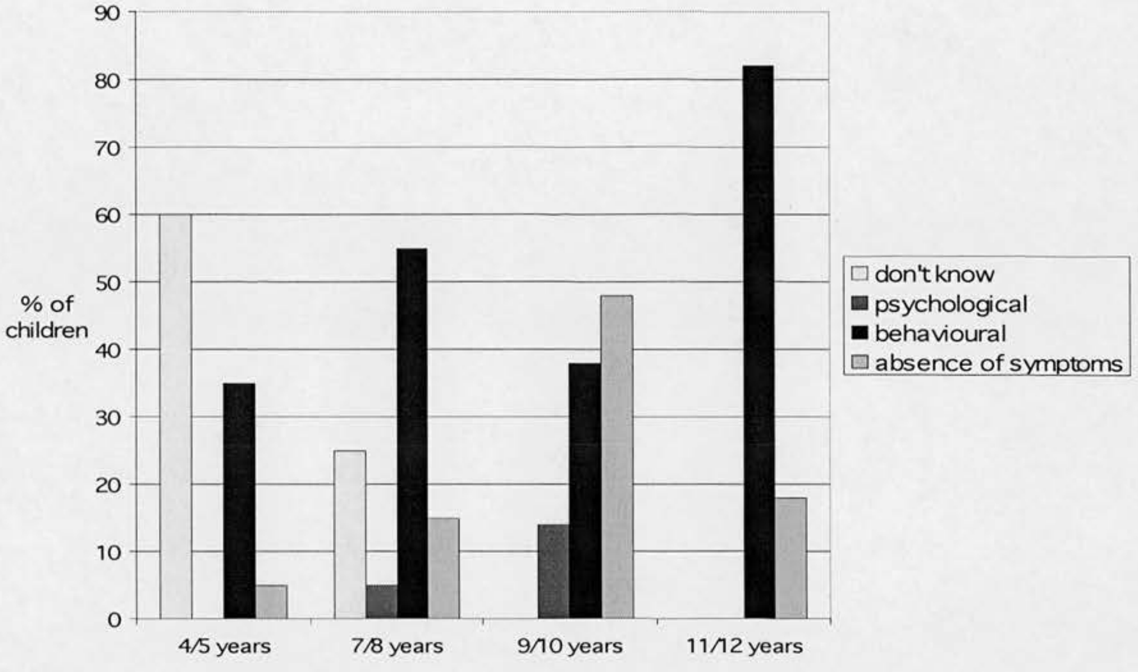


Figure 4.2 shows the percentages of participants invoking each response type for definitions of health. A different pattern to definitions of illness is seen. The most favoured category here is behavioural for the 7 year olds and the 11 year olds. The 4 years olds prefer "don't know" and the 9 year olds mainly use definitions based on absence of symptoms. Chi-square test showed responses to be significantly associated with age ($\chi^2 = 45.37$, $p < .001$).

Table 4.1: Mean scores for definitions of each illness type by age group (standard deviation)

	Cold	C pox	Asthma	Tooth	Bruise	Br leg
4 y	1.00 (0.56)	0.95 (0.39)	0.50 (0.61)	0.75 (0.55)	0.90 (0.55)	0.95 (0.51)
7 y	1.10 (0.64)	0.90 (0.31)	0.70 (0.47)	1.05 (0.51)	1.25 (0.55)	1.25 (0.64)
9 y	1.33 (0.48)	1.00 (0.32)	0.95 (0.59)	1.33 (0.48)	1.62 (0.50)	1.19 (0.68)
11 y	1.09 (0.43)	1.05 (0.21)	1.00 (0)	1.23 (0.53)	1.41 (0.50)	1.45 (0.60)

Table 4.1 shows that older children have higher scores and are therefore more likely to specify the cause of an illness than the younger children. Asthma has the lowest scores so is most commonly defined in terms of symptoms or, for the younger age groups, "don't know". The two injuries have higher scores which indicates more mention of causality than for the other illnesses.

A two-way ANOVA on the definition scores found a main effect of age group ($F (3, 79) = 7.70$, $p < .001$, $f = 0.54$), post hoc Tukey HSDs found that the 4 year olds had lower mean scores than the 9 year olds and the 11 year olds ($ps < .001$). There was also a main effect of illness type ($F (5, 395) = 13.47$, $p < .001$, $f = 0.41$). Repeated measures t-tests comparing the different illness types across all ages showed that scores for asthma were lower than scores for cold ($t (82) = 4.88$, $p < .001$, $d = 0.63$), chicken pox ($t (82) = 3.31$, $p < .001$, $d = 0.43$), toothache ($t (82) = 4.17$, $p < .001$, $d = 0.57$) and bruise ($t (82) = 6.71$, $p < .001$, $d = 0.92$). Further, chicken pox scores were significantly lower than the injuries' scores: bruise (t (82) = 5.05, p < .001, d = 0.68) and broken leg (t (82) = 3.68, p < .001, d = 0.48). No interaction effect was found.

Table 4.2: Mean scores for causality of each illness type by age group (standard deviation)

	Cold	C pox	Asthma	Toothache	Bruise	Br leg
4 y	0.65 (0.59)	0.40 (0.60)	0.55 (0.69)	0.90 (0.31)	0.95 (0.22)	0.85 (0.37)
7 y	1.00 (0.56)	0.80 (0.95)	0.60 (0.88)	0.95 (0.73)	1.00 (0)	1.00 (0)
9 y	1.19 (0.40)	1.33 (0.91)	0.85 (0.91)	1.00 (0.68)	1.00 (0)	1.00 (0)
11 y	1.00 (0.31)	1.55 (0.86)	1.18 (0.85)	1.50 (0.43)	1.00 (0)	0.95 (0.21)

Table 4.2 shows that understanding of causality mainly falls at a physical level, i.e. not above a mean score of 1. However, for the injuries it was not possible to code causality as "biological" as the causes of injuries are always physical. Therefore, a mean score of 1 for these ailments indicates that every child gave a reasonable "physical" explanation. In general, higher scores are observed in the older age groups and like the scores for "definition" it appears as though the lowest scores are obtained for asthma.

For understanding of the causality of illness, a two-way ANOVA revealed a main effect of age group (F (3, 79) = 14.26, p < .001, f = 0.74). Subsequent post-hoc tests found that 4 year olds have lower mean scores than the 9 and 11 year olds and the 7 year olds have a lower mean scores than the 11 year olds (all ps < .001). A main effect of illness type (F (5, 395) = 2.55, p < .001, f = 0.17) was found, but post hoc t-tests did not show any significant differences between pairs of illnesses.

The significant interaction effect ($F (15, 395) = 3.11$, $p < .001$, $f = 0.34$) was initially explored using one-way ANOVAs with Tukey HSD post hoc analysis (only significant differences are reported). There were significant developmental improvements between age groups for cold ($F (3, 79) = 4.59$, $p < .005$; 4 year olds have a lower mean than 9 year olds, $p < .01$), chicken pox ($F (3, 79) = 7.87$, $p < .001$; 4 year olds have a lower mean than 9 year olds and 11 year olds, $p < .01$ and 7 year olds have a lower mean than 11 year olds, $p < .05$) and toothache ($F (3, 79) = 8.07$, $p < .001$; 11 year olds have a higher mean than all other age groups, $p < .01$). There were no age differences for bruise, broken leg and asthma.

Table 4.3: Mean scores for accuracy measure of each illness type by age group (standard deviations).

	Cold	C pox	Asthma	Toothache	Bruise	Br leg
4 y	0.10 (0.45)	0.10 (0.45)	0 (0)	1.50 (0.69)	1.90 (0.45)	1.80 (0.83)
7 y	0.45 (1.14)	0.95 (1.31)	0.40 (0.82)	1.65 (0.93)	2.35 (0.59)	2.60 (0.75)
9 y	0.47 (1.08)	1.52 (1.33)	0.91 (1.09)	1.95 (0.86)	2.09 (0.54)	2.24 (0.44)
11 y	0.09 (0.43)	1.68 (1.13)	1.18 (1.22)	2.64 (0.95)	2.27 (0.55)	2.27 (0.83)

Table 4.3 shows the accuracy of explanations for causality of illness. The illness with the least accurate knowledge of causes is a cold. In particular, the 11 year olds have a low mean score for cold of 0.09, in fact, this is even lower than the score achieved by the 4 year olds. Possible reasons for this will be flagged in the discussion. The greatest accuracy of knowledge is for the injuries and there does not appear to be much

improvement due to age for these two ailments indicating that children already hold a fairly sophisticated view of injury that does not developmentally change over childhood.

A two-way ANOVA indicated a significant main effect of age group ($F(3, 79) = 16.91$, $p < .001$, $f = 0.80$) with differences in accuracy detected between the 4 year olds and all other age groups (all ps $< .001$). A significant main effect of illness type ($F(5, 395) = 82.28$, $p < .001$, $f = 1.02$) was also found. For the cross-illness post hoc comparisons, scores for toothache, bruise and broken leg were found to be significantly higher than scores for cold, chicken pox and asthma (cold - toothache: $t(82) = -10.92$, $p < .001$, $d = 1.85$; cold - bruise $t(82) = -16.27$, $p < .001$, $d = 2.64$; cold - broken leg: $t(82) = -15.23$, $p < .001$, $d = 2.42$; chicken pox - toothache: $t(82) = -5.53$, $p < .001$, $d = 0.78$; chicken pox - bruise: $t(82) = -7.89$, $p < .001$, $d = 1.11$; chicken pox - broken leg: $t(82) = -7.60$, $p < .001$, $d = 1.10$; asthma - toothache: $t(82) = -10.07$, $p < .001$, $d = 1.32$; asthma - bruise: $t(82) = -13.00$, $p < .001$, $d = 1.85$; asthma - broken leg: $t(82) = -12.62$, $p < .001$, $d = 1.76$) and chicken pox scores were higher than scores for cold ($t(82) = -4.87$, $p < .001$, $d = 0.75$).

The interaction effect ($F(15, 395) = 3.174$, $p < .001$, $f = 0.35$) was examined by using one-way ANOVAs and post hoc Tukey HSDs comparing means for different age groups for each illness type separately. There were significant age differences in accuracy for chicken pox ($F(3, 79) = 7.87$, $p < .001$, $f = 0.55$; 4 year olds have a lower mean than 9 and 11 year olds, $p < .005$) asthma ($F(3, 79) = 6.70$, $p < .001$, $f = 0.50$; 4 year olds have a lower mean than 9 and 11 year olds, $p < .05$), toothache $F(3, 79) =$

7.17, $p < .001$, $f = 0.52$; 11 year olds have a higher mean than 4 and 7 year olds, $p < .01$), bruise ($F(3, 79) = 2.85$, $p < .05$, $f = 0.33$; no pairwise differences detected) and broken leg ($F(3, 79) = 4.04$, $p < .01$, $f = 0.39$; 4 year olds have a lower mean than 7 year olds, $p < .05$). No age differences were detected for cold.

Table 4.4: Mean scores for prevention of each illness type by age group

	Cold	C pox	Asthma	Toothache	Bruise	Br leg
4 y	0.50 (0.51)	0.30 (0.47)	0.25 (0.44)	0.35 (0.49	0.55 (0.51)	0.40 (0.50)
7 y	1.00 (0.56)	0.85 (0.88)	0.40 (0.50)	0.90 (0.64)	0.80 (0.41)	0.90 (0.31)
9 y	0.90 (0.44)	1.43 (0.68)	0.57 (0.51)	1.10 (0.62)	1.00 (0)	1.00 (0)
11 y	1.00 (0.44)	1.27 (0.94)	0.91 (0.75)	1.32 (0.48)	1.00 (0)	0.91 (0.29)

Table 4.4 shows clear developmental trends with prevention strategy scores increasing across the age groups for each illness. A two-way ANOVA found a main effect of age group ($F(3, 79) = 24.32$, $p < .001$, $f = 0.96$), with differences between the 4 year olds and all other age groups (all ps < .001) and the 7 year olds and 11 year olds ($p < .001$). The main effect of illness type ($F(5, 395) = 7.84$, $p < .001$, $f = 0.31$) was further investigated using post-hoc t-tests, which showed that asthma scores were significantly lower than for all other illnesses (cold: $t(82) = 3.99$, $p < .001$, $d = 0.56$; chicken pox: $t(82) = 4.39$, $p < .001$, $d = 0.58$; toothache: $t(82) = 4.71$, $p < .001$, $d = 0.61$; bruise: $t(82) = 4.29$, $p < .001$, $d = 0.60$; broken leg: $t(82) = 3.85$, $p < .001$, $d = 0.52$).

The interaction effect ($F(15, 395) = 2.21$, $p < .01$, $f = 0.28$) was examined by comparing age differences within each illness using one-way ANOVAs with post hoc

Tukey HSD tests. There were significant age effects for all illness types: Cold ($F(3, 79) = 4.84$, $p < .005$, $f = 0.43$; 4 year olds have a lower mean than 7 and 11 year olds, $p < .05$); chicken pox ($F(3, 79) = 8.94$, $p < .001$, $f = 0.58$; 4 year olds have a lower mean than 9 and 11 year olds, $p < .001$); asthma ($F(3, 79) = 5.26$, $p < .005$, $f = 0.44$; 11 year olds have a higher mean than 4 and 7 year olds, $p < .05$); toothache ($F(3, 79) = 11.23$, $p < .001$, $f = 0.65$; 4 year olds have a lower mean than all other age groups, $p < .05$); bruise ($F(3, 79) = 9.09$, $p < .001$, $f = 0.59$; 4 year olds have a lower mean than 9 and 11 year olds, $p < .001$) and broken leg ($F(3, 79) = 14.07$, $p < .001$, $f = 0.73$; 4 year olds have a lower mean than all other age groups, $p < .001$).

Table 4.5: Mean scores for incubation time course of each illness type by age group (standard deviation)

	Cold	C pox	Asthma	Toothache	Bruise	Br leg
4 y	0.05 (0.22)	0.20 (0.62)	0.20 (0.62)	0.05 (0.22)	0.01 (0.45)	0.20 (0.62)
7 y	0.45 (0.76)	0.30 (0.73)	0.10 (0.45)	0.75 (0.91)	1.30 (0.98)	0.70 (0.98)
9 y	0.76 (0.94)	1.15 (1.01)	0.48 (0.87)	0.86 (0.85)	1.33 (0.96)	1.24 (0.99)
11 y	0.77 (0.97)	0.73 (0.93)	0.64 (0.95)	1.00 (0.69)	1.09 (1.01)	1.64 (0.79)

Table 4.5 shows how accurate the participants in each age group were in their estimations of incubation time, i.e. the time between contracting the illness and "feeling ill". Again, scores generally increase with age. The most difficulty is observed in understanding the time course of asthma and cold. Scores appear a bit higher for toothache and the injuries.

There was a main effect of age group ($F(3, 79) = 17.86$, $p < .001$, $f = 0.82$). Post hoc tests detected improvements in accuracy scores between the 4 year olds and all other age groups (all $ps < .001$) and between the 7 year olds and 9 and 11 year olds ($ps < .05$). For the cross-illness main effect ($F(5, 395) = 8.35$, $p < .001$, $f = 0.32$) , post hoc t-tests indicated that asthma has a lower mean score than bruise ($t(82) = 4.74$, $p < .001$, $d = 0.68$) and broken leg ($t(82) = 4.92$, $p < .001$, $d = 0.68$); and cold has a lower mean score than bruise ($t(82) = 4.38$, $p < .001$, $d = 0.48$) and broken leg ($t(82) = 3.38$, $p < .001$, $d = 0.48$).

One-way ANOVAs with post hoc Tukey HSDs examining age trends within illness types were employed to investigate the interaction ($F(15, 395) = 2.29$, $p < .005$, $f = 0.29$). Age differences were found for cold ($F(3, 79) = 3.80$, $p < .05$, $f = 0.38$; 4 year olds have a lower mean than 9 and 11 year olds, $p < .05$); chicken pox ($F(3, 79) = 5.40$, $p < .005$, $f = 0.45$; 4 year olds have a lower mean than 9 year olds, $p < .01$ and 7 year olds have a lower mean than 9 year olds, $p < .05$); toothache ($F(3, 79) = 6.98$, $p < .001$, $f = 0.51$; 4 year olds have a lower mean than all other age groups, $p < .05$); bruise ($F(3, 79) = 8.60$, $p < .001$, $f = 0.57$; 4 year olds have a lower mean than all other age groups, $p < .01$) and broken leg ($F(3, 79) = 11.11$, $p < .001$, $f = 0.65$; 4 year olds have a lower mean than 9 and 11 year olds, $p < .005$ and 7 year olds have a lower mean than 11 year olds, $p < .01$). There were no age trends for asthma.

Figure 4.3: Percentage of children giving each recovery strategy

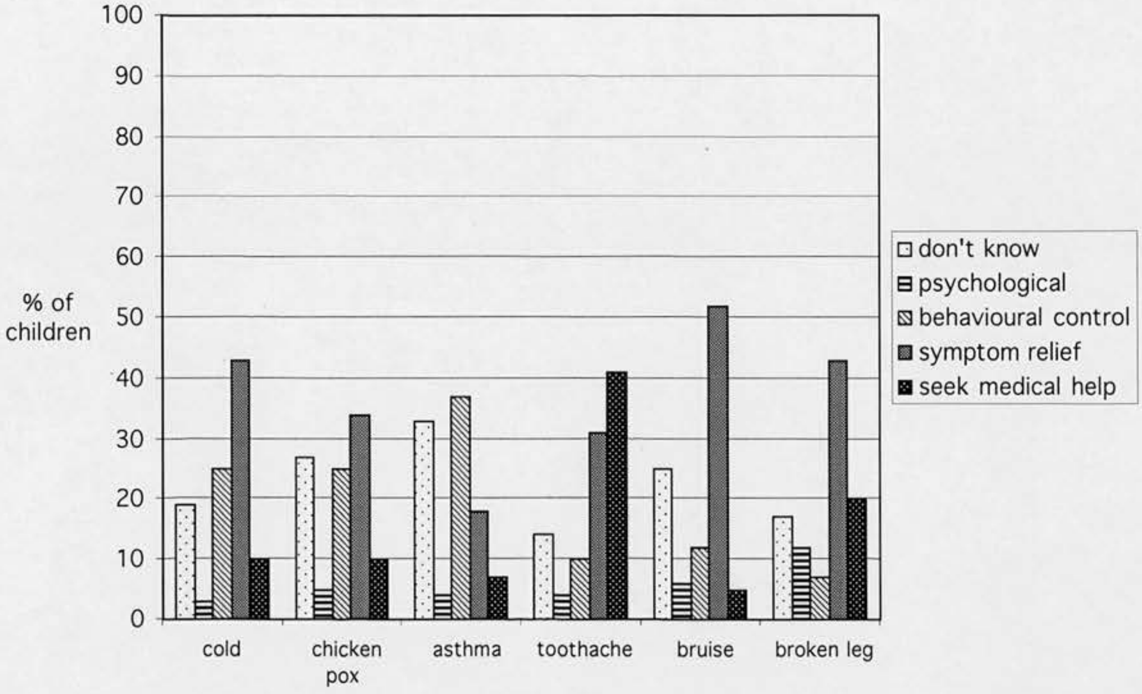


Figure 4.3 shows the percentage of children giving each recovery strategy for the six illnesses. In general the most favoured strategy is symptom relief. For toothache, most children referred to seeking medical help. As for all other illness features, asthma shows the highest number of don't know responses.

To explore this overall trend in more detail, associations between recovery strategies and age were examined for each illness type using chi-square. The results were significant in relation to cold ($\chi^2 = 29.85$, $p < .005$), bruise ($\chi^2 = 24.64$, $p < .05$) and broken leg ($\chi^2 = 27.83$, $p < .01$).

Table 4.6: Mean scores for recovery time course of each illness type by age group (standard deviation)

	Cold	C pox	Asthma	Toothache	Bruise	Br leg
4 y	0.20 (0.41)	0.30 (0.66)	0.30 (0.73)	0.20 (0.41)	0.20 (0.41)	0.55 (0.83)
7 y	0.55 (0.76)	0.95 (0.83)	0.40 (0.82)	0.45 (0.51)	0.95 (0.83)	1.00 (0.86)
9 y	1.38 (0.74)	1.62 (0.74)	0.48 (0.87)	0.71 (0.46)	1.05 (0.67)	1.62 (0.67)
11 y	1.27 (0.70)	1.41 (0.73)	0.73 (0.98)	0.77 (0.43)	1.09 (0.61)	1.41 (0.73)

Table 4.6 shows the accuracy of answers regarding time to recovery. Overall, the scores are higher than the incubation time scores indicating a better understanding of this part of the time course of illness.

A two-way ANOVA found a main effect of age group ($F (3, 79) = 26.66$, $p < .001$, $f = 1.00$) and post-hoc Tukey HSD tests showed significant increases in accuracy between the 4 year olds and all other age groups (all ps < .005) and the 7 year olds showed lower means than the 9 and 11 year olds (ps < .005). For the main effect of illness type ($F (5, 395) = 13.76$, $p < .001$, $f = 0.42$), toothache has a lower mean than cold ($t (82) = 3.79$, $p < .001$, $d = 0.47$), chicken pox ($t (82) = 5.95$, $p < .001$, $d = 0.75$), bruise ($t (82) = -3.34$, $p < .001$, 0.46) and broken leg ($t (82) = -6.45$, $p < .001$, $d = 0.88$). Asthma has a lower mean than chicken pox ($t (82) = 4.88$, $p < .001$, $d = 0.68$) and broken leg ($t (82) = -5.30$, $p < .001$, $d = 0.79$).

In relation to the interaction ($F (15, 395) = 1.91$, $p < .05$, $f = 0.27$), there were significant age differences for all illness apart from asthma: cold ($F (3, 79) = 14.91$, p <

.001, $f = 0.75$; 4 year olds have a lower mean than 9 and 11 year olds, $p < .001$ and 7 year olds have a lower mean than 9 and 11 year olds, $p < .005$) chicken pox ($F(3, 79) = 12.73$, $p < .001$, $f = 0.69$; 4 year olds have a lower mean than 9 and 11 year olds, $p < .001$ and 7 year olds have a lower mean than 9 year olds, $p < .05$) toothache ($F(3, 79) = 6.95$, $p < .001$, $f = 0.51$; 4 year olds have a lower mean than 9 and 11 year olds, $p < .01$) bruise ($F(3, 79) = 8.57$, $p < .001$, $f = 0.57$; 4 year olds have a lower mean than all other age groups, $p < .01$) and broken leg ($F(3, 79) = 7.66$, $p < .001$, $f = 0.54$; 4 year olds have a lower mean than 9 and 11 year olds, $p < .01$).

Correspondences between children's understanding of different features and different illnesses

Looking at the data in the above tables, it is clear that children have better understanding of some of the features of illness than others. For instance, mean scores for the incubation time course are particularly low when compared to the understanding of other features. How much children understand about the different illness processes depends on the illness being asked about.

It was previously discussed that children may have three micro-theories of illness, relating to contagious illnesses, non-contagious illnesses and injuries. The results of this study can be used to investigate this hypothesis. From the data reported above, it appears as though there is some correspondence between the two injuries. The mean scores for bruise and broken leg are often similar indicating that understanding may be at a similar level. However, mean scores for the cold are often lower than for chicken pox so it cannot be concluded that children understand these two contagious illnesses according to the same biological theory. Further, there is little correspondence between toothache and asthma, supporting the idea that children develop different levels of understanding for different non-contagious illness.

These findings are based on merely eye-balling the data and correlational analyses would shed further light on this issue. Therefore, a single score for each illness was calculated by summing together the scores for definition, causality, accuracy, prevention and time course. These scores were then correlated with each other and it was found that each illness was positively and significantly correlated with every other illness. Taking these results as given would indicate that understanding of illness is not constructed around three micro-theories, instead it would imply that understanding of all illnesses and injuries is interlinked. However, an important caveat is that the scale for each illness is quite constraining (i.e. 0 – 14) so no clear conclusions can be drawn from this.

4.6. Discussion

This study has shown the development of children's understanding of health and illness between the ages of 4 years and 11 years. As predicted, children's knowledge of illness becomes more sophisticated and accurate with age. This was found both for general definitions of health and illness and also for knowledge of specific illnesses. Furthermore, it was expected that children would hold differing levels of knowledge for the specific illnesses investigated and this was supported with knowledge of injuries being much greater than the illnesses, with a particularly low understanding of asthma. This section will discuss each of these findings in turn and then consider understanding of each specific illness separately.

In this study, the most frequent definition of illness was based upon the presence of symptoms and feeling poorly. Even some of the 4 year olds were able to define illness in this way, although the majority answered "don't know". In contrast, definitions of health were more commonly based on behavioural factors, such as healthy eating and exercise, therefore indicating health is not necessarily defined as the opposite of illness. Chapter 2 discussed how various researchers have suggested that health and illness are different but overlapping constructs (Millstein & Irwin, 1987; Schmidt & Frohling, 2000). Millstein and Irwin (1987) looked at these concepts among adolescents and found that the degree of overlap varied with age with older adolescents seeing health as more than just absence of illness. The results of the present study extend this by looking earlier into childhood and they show polarisation of the concepts occurring in this age range with the 9 year olds giving definitions that appear to associate health with absence of illness but the 11 year olds moving away from illness-related definition and giving more definitions based on health-related behaviours.

It is well documented that children's understanding of illness becomes more sophisticated with age (e.g. Bibace & Walsh, 1981; Charman & Chandiramani, 1995) and this study supports this further by including a wider range of illnesses and processes than previous studies. The most commonly found effect of age in this study was that 4 year olds display less understanding that the older age groups (9 year olds and 11 year olds). In addition, the 7 year olds also frequently showed differences from the 4 year olds, for example, accuracy of judgements of time course. This will now be discussed with more detail of the types of response given by each age group.

At 4 years, children mainly respond 'don't know'. They give some responses for definition questions which can be correct but are only based on symptoms or generally feeling unwell, they give very little detail. With regards to causality, irrelevant or incorrect responses are common e.g. colds are from bubbles. Where responses are correct they are very basic and involve little detail. They are not easily coded as biological and are more likely to reflect a physical model of explanation. There is clear development between this age group and the 7 year olds. The analyses found little difference between the 7 year olds and the 9 year olds so this age group will be considered as one. The explanations given by the 7 – 9 year olds include a much reduced number of irrelevant or wrong responses. This is especially true for definitions and causality but they are still very basic and lack accuracy or biological detail where relevant. At 11 years, children have more accurate understanding and can give detailed explanations of biological mechanisms.

Comparing across illnesses for each process has shown that children can have understanding of one ailment without understanding another to the same degree. For example, although accuracy of explanations of causality of toothache was quite high across all age groups, accuracy of explanations for asthma, another non-contagious illness, was significantly lower. This indicates the importance of considering the variation in understanding of specific illnesses when researching children's concepts.

Looking at differences across illnesses is also relevant to Williams and Binnie's (2002) suggestion of the possibility of three separate reasoning systems for understanding illness as outlined in Chapter 2. The correlational analyses in this study would appear to suggest that there are not separate reasoning systems for understanding contagious illnesses, non-contagious illnesses and injuries but this will be further investigated in the subsequent studies of this thesis. Consequently, full consideration to this possibility will be given in the general discussion of Chapter 7, when the results of the intervention studies to be reported in Chapter 5 and 6 can also be discussed.

In order to provide a complete overview of the findings and interpret them in respect to previous literatures in both developmental and health psychology (see Chapter 2), each illness will now be considered separately. The following paragraphs discuss understanding of causality as this has been the focal point of previous literature and it is therefore easy to draw comparisons. However, as this study aims to give a more comprehensive picture of what children understand about illness, the findings of what children understand about other illness processes are also considered.

Despite the cold being a common contagious ailment of which children are likely to have extensive direct experience, children held misconceptions of the causality of the cold. Specifically, children at all ages were more likely to refer to cold weather than contagion to explain the causality of colds. Sigelman and Alfeld-Liro (1995) suggest this misconception may be prevalent due to the nature of colds. The symptoms of a cold can be described as cold-like e.g. runny noses and chills and children tend to get more colds in the winter than in the summer. This misconception may also have a linguistic basis as the same word is used to describe the weather and the illness. More importantly, however, children may be frequently told that they will catch a cold if they go out in the cold weather without proper protection. This indicates how powerful parental influence is in giving children advice related to health. Despite a naïve conception of causality of colds, the children in this study did show fairly sophisticated reasoning of the other aspects of colds such as definitions, prevention, and recovery.

Knowledge of the causality of chicken pox was greater than for cold which further suggests it is not a lack of understanding of contagion that underlies misconceptions of cold. This study shows that children are capable of conceptualising the causality of chicken pox in biological terms even at age 4 years. However, explanations of the biological mechanisms involved in contagion do not become accurate until age 9 years. Knowledge relating to chicken pox specifically has only been investigated by a handful of studies (e.g. Charman & Chandiramani, 1995; Peltzer & Promtussananon, 2003) but knowledge of contagion has been extensively studied (e.g. Kalish, 1996a, 1996b; Solomon & Cassimatis, 1999). The finding of this study that children are capable of referring to a biological framework of understanding at age 4 years without having knowledge of the specific mechanisms at work would appear to bridge the gap between contradictory findings by these studies. It is possible that children have an idea that some illnesses are caught off other people (Kalish,1996a, 1996b) without knowing the details (Au & Romo, 1999; Solomon & Cassimatis, 1999). In addition, the older age groups of children have the beginnings of an understanding of the incubation period involved in this contagious illness and the time to recovery. However, the younger children frequently answer that someone would get chicken pox immediately showing little understanding of the biological processes involved in the reproduction of viruses and this effect on the body.

Of all the illnesses investigated in this study, understanding of asthma was the lowest. Asthma is a non-contagious illness and there is extensive literature on children's understanding of asthma in terms of health care and practice (Eiser, Town & Tripp, 1988; Ireland, 1997; McQuaid et al., 2002). This study adds to this literature by considering a general sample of children and the development of their understanding of asthma in relation to other illnesses. In terms of biological understanding, causality of asthma is sometimes understood in terms of inheritance. Although it is not entirely clear what causes asthma, older children in this study considered there to be a genetic component. Physical causes of asthma reported by children included triggers for allergies and exercise which were noted by all age groups except the 4 years. Understanding of the other features of asthma was low across all age groups. Recovery strategies specified by the older age groups included using inhalers and avoiding behaviours such as running which might trigger an attack.

Children in the 11 year old age group were capable of giving quite sophisticated and accurate accounts of the decay processes involved in toothache and even children in the younger age groups were able to identify physical/behavioural factors that would contribute to toothache such as not brushing their teeth. This contradicts previous research which found that children overextended contagion as an explanation of toothache (Kister & Patterson, 1980) and expands on Siegal's (1988) finding which argued children did not perceive toothache as a contagious illness but did not suggest how children understood the cause of toothache. Knowledge of prevention of toothache was high which reflects the efforts of community and school health programmes to educate children in the benefits of oral hygiene. The most frequently mentioned recovery strategy was going to the dentist and there was some understanding displayed as to the time course of toothache.

Children in all age groups showed comprehensive knowledge of both injuries: bruise and broken leg. Definitions were attempted by all age groups and a mix of symptoms and causality was mentioned. Causal explanations were all physical but more detailed and accurate explanations were given by the older children. Interestingly, some psychological strategies for recovery were mentioned here which were not found for the illnesses. Prevention strategies mainly focused on "being careful" and there was some degree of awareness of the time course of injuries. This finding that knowledge of injuries is greater than of illness supports Williams and Binnie (2002) who suggest that this is due to greater experience with minor injuries, the more apparent causes of injuries and the more observable external effects of injuries.

It is a prevalent finding in this study that children understand more about illness than the domain-general research from the 1980s would suggest. There are two possible reasons for this. Firstly, early research did not use child-friendly methodologies. This present study used a child-sensitive, open-ended questioning method which did not place unnecessary task demands on any of the age groups. It is acknowledged that due to limited verbal ability, the 4 year olds may not have been capable of displaying their full understanding but they were still able to participate and offer answers for all of the interview items. Secondly, there is more awareness of health and illness in the public domain and a greater emphasis on health education in schools. This could be leading to increased interest and greater understanding of health-related issues in this generation of children compared to the early 1980s which indicates the potential of successful health education.

This discussion section has described how the first aim of this study has been fulfilled. However, in addition to providing a study on what children understand about illness, this study also aimed to provide a baseline measure for studies 2 and 3 and identify areas of understanding that would benefit from intervention. As stated by previous research, it is vital to ascertain exactly what children know about illness before teaching them about it, making this an important aim (Au et al., 1999; Williams & Affleck, 1999). Firstly, it can be noted that understanding of injuries was almost at ceiling level especially in the older age groups and it is therefore felt that an intervention programme would be fruitless. However, understanding of both contagious illnesses and non-contagious illnesses has the scope to improve. A consideration of both the results from this study and previous developmental literature suggests that children have separate systems of understanding for each specific non-contagious illness (Williams & Binnie, 2002). Therefore, any intervention aimed at improving understanding of non-contagious illnesses would have to be specifically tailored to improving knowledge of one specific illness and it would be difficult to improve understanding in this area as a whole. In contrast, Chapter 2 describes literature which argues that contagious illnesses are conceptualised by children as part of a model of infection and relates this to theory-building (Kalish, 1999). Thus, it could be argued, different contagious illnesses are understood in similar ways. Chapter 2 argued further that children do not hold a full understanding of the biological processes and the results from this study support this notion. Therefore, timely and age-appropriate intervention could be successful in addressing children's gaps in understanding of contagion and contagious illnesses and this will be the aim of the next two studies to be reported in this thesis. However, to further investigate the premise that children's understanding of illness may be fragmented into different systems of reasoning for contagious illnesses, non-contagious illnesses and injuries (Williams & Binnie, 2002), a range of illnesses will be included in the pre- and post-test of an intervention study to assess the generalisability of the interventions to other illnesses.

4.6. Conclusions

This study aimed to give a comprehensive picture of children's understanding of illness than previous research by investigating knowledge of specific contagious illnesses, non-contagious illnesses and injuries. This has added to the current literature by considering cross-illness differences, which are important for designing health education interventions and how to talk to children about different illnesses. This study had two purposes as outlined at the start of the chapter. Firstly, gaps in previous literature meant that research was needed to give a comprehensive picture of children's illness concepts. As a consequence of this study, knowledge of what children understand about different illnesses has been advanced. In sum, it has been shown that children are capable of talking about illness as young as age 4 years and their explanations and understanding become more complex with maturity. It is also likely that children understand contagious illnesses, non-contagious illnesses and injuries in different ways (see Chapter 7 for further discussion).

The second aim of this study was to provide a baseline measure of children's understanding of illness in order to develop an effective intervention. Discussion here has shown that children's understanding of contagious illnesses will be targeted by the interventions. Leading on from this study, the next chapter will therefore investigate the effect of different intervention methods, group discussion and factual information for improving understanding of colds and chicken pox. In order to test for generalisability, non-contagious illnesses will be included at pre- and post-test. Therefore, all illnesses in the next study are the same as in this study allowing comparison across the empirical work of this thesis.

Chapter 5:

Study 2: A Comparison of Group Discussion and Factual Information as Interventions to Improve Knowledge of Illness

5.1. Introduction

This chapter will report a study that examines different intervention methods for improving children's understanding of illness. Chapter 3 discussed the findings of research which found that intervention programmes that take an "intuitive knowledge" perspective are useful in health education, i.e., in improving knowledge of AIDS (Au et al., 1999; Sigelman et al., 1996) and drug behaviour (Sigelman et al., 2004). However, these studies have used different teaching methods in combination, such as group discussion, guided lessons, provision of factual information, and do not indicate which parts of the curriculum are most effective in improving understanding or what processes lead to changes in understanding. Previous research has also considered the use of three main intervention types for improving biological understanding in detail: direct experience, provision of factual information and collaborative learning. However, there is a lack of research which investigates the efficacy of these intervention types in detail for use with illness concepts. Therefore, further research is needed to identify what the most appropriate intervention method is for improving children's understanding of illness. This study will look at factual information, in the form of explanations, and collaborative learning.

There are various points for further investigation flagged up in Chapter 3 that will be addressed by the study to be reported in this chapter. In terms of factual information, most of the previous developmental research assumes congruence between children's naïve knowledge and formal knowledge (Pines & West, 1986). However, the results of Study 1 would suggest that understanding of illness is characterised by misconceptions in places (e.g. colds are caused by cold weather). This suggests that the provision of basic facts will not be enough to improve understanding in this area. Instead, some effort will be needed to promote engagement with the task. There are two possible ways of doing this. First, instead of just providing 'basic facts', full explanations of biological processes may be more effective. Indeed, it is specific details about illness processes that children have been shown to lack (e.g. Au & Romo, 1999). Therefore, the explanations will be of more interest to the children and will lead to a greater motivation to complete the task. It is further possible that the explanations provided will work in conflict mode with the children's ideas.

Second, the context in which the facts are presented could be altered to attempt to promote engagement. Previous research has presented facts to the child without any activity to engage them (e.g. Springer, 1995; Williams & Affleck, 1999). It is the aim of this study to engage the children in tasks that will require them to express their own thoughts on illness which will then be challenged by the formal factual knowledge.

For group discussion, there is a huge body of research on other areas of conceptual understanding such as physics. Previous work has focused on such matters as the make-up of groups and the types of conflict that is conducive to positive change. As this has been investigated in great detail by others (see Joiner. Littleton, Faulkner & Miell, 2000), this thesis will look at a different aspect of group work. To be specific, the combination of group work with factual information will be investigated.

Therefore, three intervention conditions will be examined. First, the explanations will be combined with an individual task that aims to engage children with the facts. Second, explanations will be combined with group discussion, which has previously found to be effective at promoting cognitive conflict and should therefore be even more effective than the individual task at promoting engagement. Although studies have combined these two intervention methods before, it has been without proper control (Myant & Howe, 2002; Williams & Binnie, 2002). Therefore, a group discussion condition without facts or explanations will also be included to allow detailed comparisons across all three conditions.

Considering the array of research on children's illness concepts and the results of Study 1, contagious illnesses were identified at the end of Chapter 4 as the best target for intervention and it was decided that non-contagious illnesses and injuries would not be targeted by the interventions. As well as the findings of previous research on children’s illness concepts, there are also issues arising from the discussions in Chapter 3. Firstly, health education programmes based on cognitive development theories have shown that interventions are most effective when they build on children's theoretical knowledge on health and illness (Au, Romo & Dewitt, 1999; Sigelman et al., 2003) and this fits well with the notion that understanding of contagion may be considered a naïve theory (Kalish, 1999). Secondly, it was shown that children's understanding of contagion has been found to be more amenable to intervention than non-contagious illnesses (Myant & Howe, 2003).

The results of Study 1 also helped identify age groups, 7 and 11 years, which would benefit from intervention. To target interventions at these age groups also has a strong practical rationale as research has shown children under 7 years are not likely to benefit fully from collaborative learning techniques and age 11 years is an age where benefits are maximised (Tomasello, Kruger & Ratner, 1993). These age groups have also been used successfully in other intervention studies (e.g. children of 7 years were used in Williams and Binnie's (2002) study and children aged 8 – 12 years participated in Williams and Tolmie's (2000) research).

The findings of this study will have clear implications for health education and health practice as it is of benefit to know what the best methods for improving children's understanding of illness are. However, it is also likely that the results will hold implications for theories of cognitive development (Chapter 1). According to a domain-general account, it is argued that children cannot be taught about illness or told details of their condition that is beyond their cognitive capabilities at a certain stage (Burbach & Peterson, 1986). However, a domain-specific perspective on cognitive development does not place such restrictions on children's cognition. Therefore, children should be able to learn within a domain independently of the stage reached in other domains of knowledge. Additionally, the results of intervention studies can also help identify how children learn about illness e.g. through the rote memorisation of facts or through conceptual change.

5.2. The Present Study

The objectives of this study are to develop and compare different intervention methods for improving seven year-olds and eleven year-olds understanding of contagion. The interventions were a group task including explanations, a group task and an individual task including explanations. The explanations provided detailed accounts of biological mechanisms with a more explicit focus on explaining how something happens (e.g. how contagious illnesses are caught). It is expected that this would be effective, as this has been shown to be the type of understanding children lack (Au & Romo, 1999). Given the previous research, it was hypothesised that conditions involving peer group discussion would lead to greater pre- to post-intervention improvement than an individual condition. It was also of interest to examine the effects of the explanations combined with group discussion but it is unclear, on the basis of previous research, if they would be further facilitative.

5.3. Method

5.3.1. Participants

Children from two age groups: seven years (N = 48, 29 boys, 19 girls: M = 7,9; range = 7,3 to 8,4) and eleven years (N = 48, 26 boys, 22 girls: M = 11,9; range = 11,5 to 12,2) participated in this study. Participants were recruited through the same process described in Chapter 4 of gaining permissions from local authorities, schools and parents in Edinburgh and East Lothian, Scotland. All children were white Caucasian.

Social background

Using free school meal entitlement as an indicator of deprivation, one of the schools visited in this study was high SES, two were mid SES and one was low SES.

5.3.2. Materials

Pre-test/Post-test

The interview schedule for the pre-/post-test contained questions relating to four common illnesses. Cold and chicken pox, the focus of the interventions, were chosen as examples of contagious illnesses. Two non-contagious illnesses, asthma and toothache, were included to determine whether the effects of the intervention would generalise to non-contagious illnesses. Study 1 showed that children in this age range have some knowledge of these illnesses and are capable of discussing them during an interview. The materials used were the same as Study 1 with each illness introduced via a vignette describing a child character displaying symptoms of the illness, followed by a series of questions. The full interview schedule is included in Appendix I.

For example:

This is Sally. Sally has lots of spots all over her face and body. She also has a sore head and is very tired. This is because she has chicken pox.

Definition: Can you tell me what chicken pox is like?

Causality: How do you think Sally got chicken pox?/Why would that make Sally get chicken pox?

Time course incubation: How long after getting chicken pox would Sally start to feel bad?/ Why would it take that long?

Recovery: What could Sally do to make herself feel better?/ Why would that make Sally feel better?

Time course recovery: How long would it take for Sally to feel better?/ Why would it take that long?

These questions were all open ended which allowed children to express their spontaneous thoughts.

Intervention

There were three intervention conditions each with two purpose-designed work books, one focusing on chicken pox and one on the cold. The work books were kept consistent in terms of content and pictures across the three intervention conditions. However, they differed systematically in order to test the effectiveness of different elements of instruction for learning as outlined below.

Group + explanations task: This condition started with a series of questions about cold and chicken pox and children were required to indicate their answers on fixed choice response cards (see Appendix III). The two specially designed work books for this condition (one for cold and one for chicken pox) provided information in sequence about causality, incubation time course, recovery strategies and recovery time course. Specific instructions were given which guided the children through each of their response cards on the illness processes. For example, the first item in each work book was causality and the children were asked to take turns to read out the answer from their response card. This method was used in line with Howe et al. (1990) who found that children's public assertions of particular viewpoints helped facilitate debate. This was argued to be because once children took a public position, they then had to defend it, rather than hide behind the potentially dominant views of others. The work book then required the children to arrive at a consensus about the best answer to this question and they were asked to fill in the blue card with the agreed answer. Additional blue cards were provided to write down the reason for their answer. Once the blue cards were filled in, feedback was provided on their answer. In this task, part of a story about a child's experience of the illness was included (see below for details of the factual story). The part of the story included after the question on causality concerned how the child character caught the illness. Then, feedback cards were provided giving the correct answer and explanation. The children were led through the other illness processes in the same way and the rest of the story was incorporated after the appropriate illness process, i.e. information on time course came after the children had discussed time course. The stories were included to give key facts about the symptoms, causality, time course and recovery of the illnesses. They were written in a similar age-appropriate style to the stories used by Williams and Affleck (1999) but included explanations of biological mechanisms to see if showing children how certain key facts are interrelated is beneficial. The stories were illustrated with cartoon pictures. See Appendix IV for the workbook used in this condition, including the factual information.

Group task: This task used similar materials as the group + explanations task. As above, questions and response cards were provided at the beginning of the task and two work books led the children through each of the illnesses. However, no story was included in these work books so the only feedback children received was from the feedback cards. This condition investigated the efficacy of group discussion alone. An example of a workbook used in this condition is given in Appendix IV.

Individual task: This condition looked at the provision of explanations without group discussion by including the questions and response cards from the group tasks, but without the group discussion component. The two work books for the individual task were of a similar format to the work books used in the group plus explanations task. However, instead of asking the children to discuss their answers in groups, they were asked to think about them individually and then indicate whether they still thought their answer was right. This allowed reflection on their original position and replaced the group discussion. There was also space allocated in the booklet for them to write a reason for their answer. After this, relevant parts of the story as in the group + explanations task were included. Direct feedback of the correct answers and reasons was then given. Appendix IV includes an example of this condition.

5.3.3. Procedure

Pre-test

The children were interviewed individually out of class. They were told they were going to be asked some questions about different illnesses, that there were no right or wrong answers and that they were free to leave the interview situation at any time. The order of the illnesses was randomised but the questions asked about each illness always followed the same order. The interviews were tape-recorded and lasted around 10 minutes.

Intervention

The children in each age group were randomly assigned to one of the three intervention conditions. This was done using the class list. The first child in the register and every third child after that were placed in the group + explanations condition; the second child and every third child after that were put in the group condition; finally, the third child and every third child after that were assigned to the individual + facts condition. This resulted in equal numbers of children from each age group in each condition. The interventions took place one week after the pre-tests.

Group + explanations condition and group condition: Children in both group conditions were taken out of class in groups of four and seated round a table. They were asked the initial questions about the two contagious illnesses and asked to answer the questions individually by ticking the correct answer on their answer cards. The children were then led through the first page of the first discussion booklet by the researcher. After ensuring the children were comfortable with the task, the children were left on their own to work through the rest of the booklet and the second booklet. One child was assigned as the reader and read out all the instructions from the intervention booklet, and in the case of the group + explanations condition, the story as well. When the children had worked through the two workbooks and thus had discussed both illnesses, they were asked to inform the researcher that they had finished. This procedure is similar to that used by Williams and Tolmie (2000).

Individual task: The individual task was held out of class with four children seated round a table. The procedure followed was the same as with the group tasks with the children answering the initial questions on cold and chicken pox. The children were then required to work individually through the two workbooks which led them through each of the questions and included the stories.

Note on in-task explanation scores: As already described, in each of the intervention conditions, the children were asked questions at the beginning that were then used to prompt discussion, in the case of the group conditions, or prompt further thought in the case of the individual condition. After a final answer had been decided upon, children were then asked to think of a reason for their answer and to write this down. These answers were then collected and analysed and are referred to as "in-task explanation scores". As the questions during the intervention were similar to the ones in the pre- post-test (i.e. causality, time course incubation, recovery, time course recovery) then the same coding scheme (see below) could be applied. However, an important caveat is that these answers were written, rather than verbal, so they may achieve a lower score depending on the ability of the child. Some of the younger children, in particular, may have problems with writing down detailed explanations of illness.

Post-test

Identical materials and procedures were used for the post-test as were used in the pre-test. In their studies, Howe, et al., (1992) and Tolmie et al. (1993) found that delayed post-tests of between six and eleven weeks showed greater pre- to post-test change as an effect of the interventions than immediate post-tests. Therefore, the post-tests took place six weeks after the intervention.

5.3.4. Coding

Although the pre/post-test remained similar to the interview schedule used in Study 1, a new coding scheme was developed for use with the responses from this study. This was felt appropriate as more sensitive measures would be needed to detect pre- to post-test differences. Like Study 1, content analysis was used to code the responses (see Weber, 1995; Krippendorff, 1980). Two coders used 15% of the response scripts to devise appropriate categories which were then used to analyse the remaining response scripts by the two coders. Overall agreement ranged from 83% to 89% (full details in Appendix V). The categories for each question did not have to be as broad as Study 1 as injuries were no longer included in this study. Therefore, each question included more categories and higher scores indicated a more sophisticated response. Due to the high level of detail captured from this coding scheme, it was not felt necessary to include an accuracy measure. Additionally, this coding scheme was used to categorise the explanations generated during the intervention tasks giving an in-task measure of group compared to individual performance. Full details of the coding scheme for this study are given in Appendix V.

5.4. Results

The analysis for this study was based on the methods used for Study 1. The data were judged to be suitable for parametric testing for the same reasons outlined in Chapter 4. Thus, the data were analysed using parametric statistics in the form of illness type (cold, chicken pox, asthma, toothache) x intervention condition (group + explanations, group, individual + explanations) x age group (7 years, 11 years) three-way ANOVAs. This procedure was used to analyse the pre-test scores, the pre- to post-test change scores and the in-task explanation scores. Any main effects were then examined by use of post hoc t-tests with corrections for the significance values or post hoc Tukey's HSD procedure. Interaction effects were explored with the use of one-way ANOVAs and post hoc Tukey's HSD. Further t-tests investigated the differences between the post-test scores and pre-test scores for each of the illness processes. Effect sizes reported are Cohen's d for t-tests and Cohen's f for ANOVAs (Cohen, 1988).

To simplify the analysis and make it more manageable, it was decided to create a single score for each illness instead of analysing by each illness process (which would make cross-illness comparisons very complicated). These illness scores could then be compared across age group and intervention condition as well as with each other through the employment of one ANOVA. The illness scores were created by adding together the scores for definition, causality, time course incubation, recovery and time course recovery. To determine that this would not mask any effects and all processes were "related", alpha coefficients were calculated for each illness. Reassuringly, the alpha values were all of a satisfactory level and ranged from 0.58 for cold to 0.74 for asthma. (Chicken pox = 0.70 and toothache = 0.67).

For the pre-test results, a three way (illness type x intervention condition x age group) ANOVA showed a main effect of illness type ($F(3, 270) = 35.79$, $p < .001$, $f = 0.63$). Post hoc t-tests with Bonferroni corrections showed that chicken pox had lower mean scores than cold ($t(95) = 3.78$, $p < .001$, $d = 0.41$) and toothache ($t(95)$

= 3.54, $p < .001$, $d = 0.32$) and the mean score for asthma was significantly lower than all other illnesses (cold: $t(95) = 3.48$, $p < .001$, $d = 0.94$; chicken pox: $t(95) = 4.77$, $p < .001$, $d = 0.52$; toothache; $t(95) = 7.94$, $p < .001$, $d = 0.83$). There was also a main effect of age group ($F(1, 90) = 23.61$, $p < .001$, $f = 0.51$) with the 11 year olds having higher mean scores

Table 5.1: Mean pre- and post-test scores by intervention condition and age group (standard deviation)

		Pre-test			Post-test		
		Gp + explns	**Gp**	**Ind**	**Gp + explns**	**Gp**	**Ind**
Cold:	**7 y**	7.81 (2.81)	7.94 (2.64)	7.00 (1.31)	9.75 (2.75)	8.37 (2.87)	8.44 (1.93)
	11 y	9.38 (2.15)	10.69 (2.55)	9.63 (2.57)	13.69 (2.36)	11.81 (2.74)	12.56 (3.56)
C pox:	**7 y**	8.06 (2.64)	6.63 (3.46)	5.87 (2.44)	10.25 (2.38)	7.44 (2.87)	8.00 (2.94)
	11 y	9.00 (3.48)	8.12 (3.11)	7.75 (2.21)	12.06 (3.57)	10.75 (2.98)	10.37 (3.95)
Asthma:	**7 y**	5.25 (2.69)	4.25 (3.49)	4.75 (2.56)	5.87 (2.92)	5.00 (2.76)	5.19 (2.43)
	11 y	7.63 (3.24)	6.56 (3.28)	6.94 (4.32)	7.38 (3.52)	8.88 (3.20)	8.81 (2.86)
Toothache:	**7 y**	7.25 (2.52)	8.00 (2.66)	6.63 (1.62)	7.94 (1.73)	8.81 (1.87)	7.56 (1.86)
	11 y	9.69 (3.00)	10.13 (2.36)	9.31 (2.98)	9.12 (1.86)	9.62 (2.45)	9.37 (4.49)

Figure 5.1: Mean pre-test scores by age group

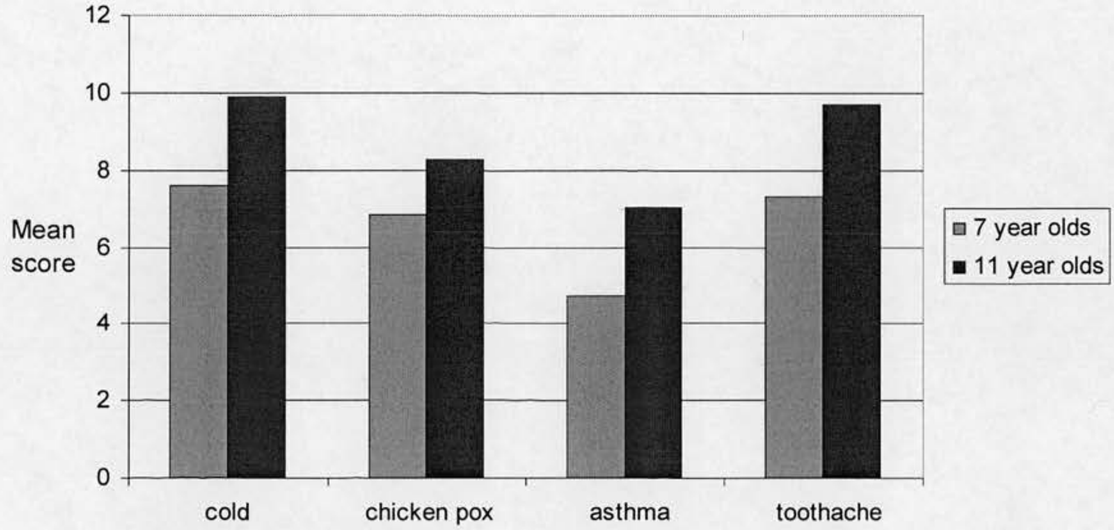
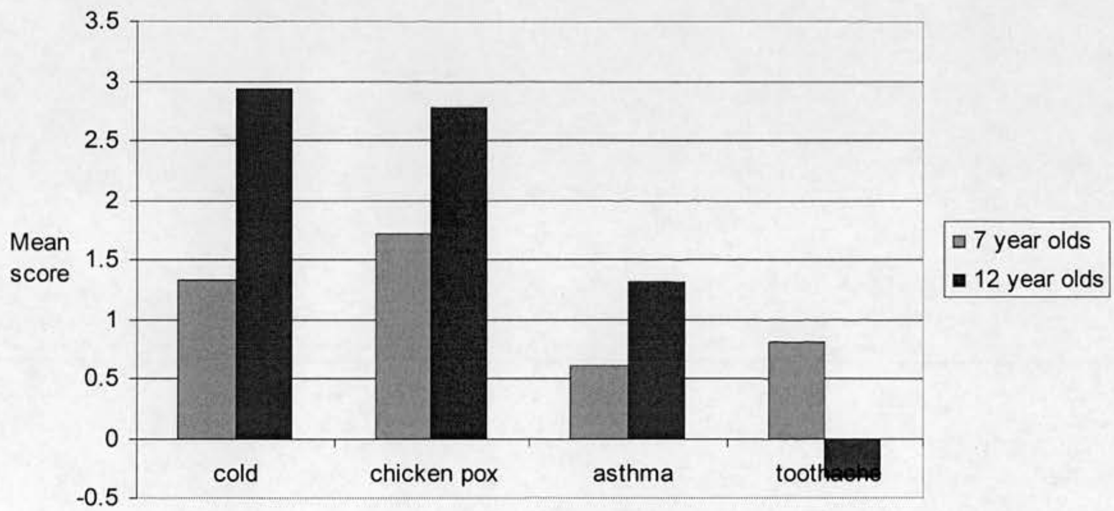
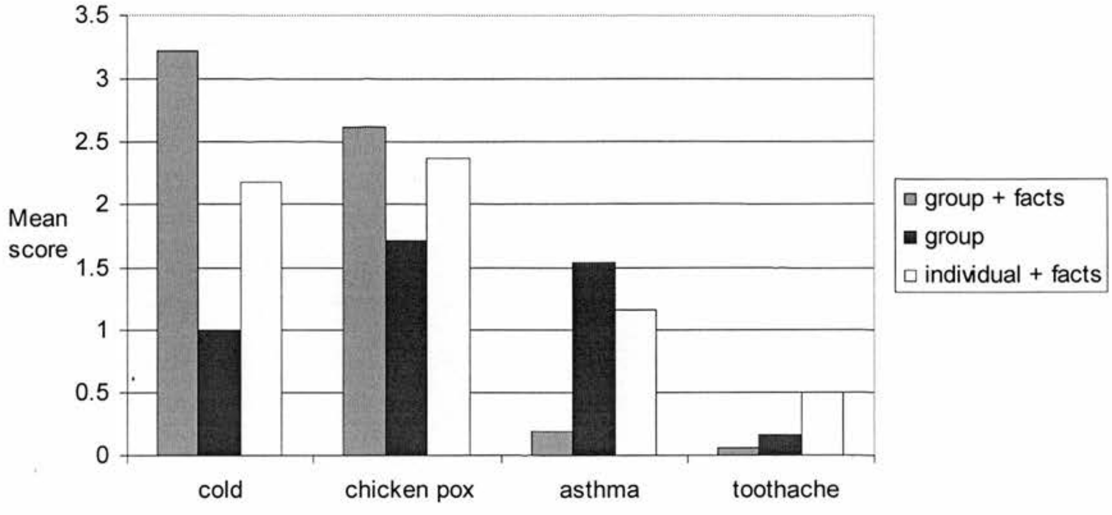


Figure 5.2: Mean pre- to post-test change scores by age group



than the 7 year olds (see Figure 5.1). There was no effect of intervention condition suggesting that there was no difference between the intervention groups at pre-test.

Figure 5.3: Mean pre- to post-test change scores by intervention condition



Pre-test scores were subtracted from the post-test scores to give a measure of pre- to post-test change (shown in Figures 5.2 and 5.3). This is a procedure that has been employed by previous intervention studies (e.g. Williams & Tolmie, 2000).

First, it is important to determine whether these change scores are significantly different from zero overall. Therefore one-sample t-tests were used to compare mean change to zero and the results are shown in Table 5.2. As can be seen, change was significantly different from zero for cold and chicken pox across all intervention conditions.

Table 5.2: One sample t-tests comparing mean change to zero

Illness	Intervention	Mean change	t-value
Cold	Group + explns	3.22	7.07**
	Group	1.00	2.35*
	Ind + explns	2.19	4.11**
Chicken pox	Group + explns	2.63	5.37*
	Group	1.72	3.55**
	Ind + explns	2.38	4.54**
Asthma	Group + explns	0.19	0.43
	Group	1.53	2.72*
	Ind + explns	1.16	2.21*
Toothache	Group + explns	0.06	0.16
	Group	0.16	0.33
	Ind + explns	0.50	1.20

**p<.001; *p<.05

A three-way (illness type x intervention condition x age group) ANOVA revealed a main effect of illness type ($F (3, 270) = 13.97$, $p < .001$, $f = 0.39$). This was investigated using post hoc t-tests with Bonferroni corrections. Cold had significantly higher change scores than asthma ($t (95) = 2.86$, $p < .005$, $d = 0.42$) and toothache ($t (95) = 4.99$, $p < .001$, $d = 0.73$), chicken pox had significantly higher change scores than asthma ($t (95) = 3.02$, $p < .005$, $d = 0.45$) and toothache ($t (95) = 5.45$, $p < .001$, $d = 0.76$).

The illness type x age group interaction ($F(3, 270) = 5.35$, $p < .001$, $f = 0.24$) indicated that there were significant differences between the age groups for cold ($t(94) = 2.91$, $p < .005$, $d = 0.60$) but not for the other illnesses. For the illness type x intervention condition interaction ($F(6, 270) = 2.89$, $p < .01$, $f = 0.25$), post hoc ANOVAs showed that there were significant differences between the intervention conditions for cold ($F(2, 93) = 5.51$, $p < .005$, $f = 0.34$), with the group + explanations condition having significantly higher post-test scores than the group condition ($p < .005$). There were no differences between the intervention conditions for the other illnesses.

A series of related t-tests were computed to test for differences between the pre- and post-test scores for each of the illness items. The use of multiple t-tests increases the likelihood of a type I error. Therefore, Bonferroni corrections were made to increase the accepted level of significance for these analyses $p < .002$.

As Table 5.3 (i) shows, the group + explanations condition improved pre- to post-test on the causality and incubation time course of the contagious illness items. There were no differences between pre- and post-test scores for the non-contagious illness items in this condition.

Table 5.3: Mean scores at pre- and post-test for each illness item by intervention condition

(i) Group + explanations

	Pre-test M	Post-test M	t (31)	Cohen's d
Cold definition	2.66	3.03	2.10	0.44
Cold causality	1.38	2.63	7.19*	1.39
Cold incubation time	0.84	2.03	4.79*	0.92
Cold recovery	1.84	2.25	2.62	0.55
Cold recovery time	1.78	1.78	0	0
Chicken pox definition	3.00	3.06	0.42	0.09
Chicken pox causality	1.16	2.16	5.11*	0.93
Chicken pox incubation time	0.81	1.81	3.66*	0.95
Chicken pox recovery	1.97	2.16	0.84	0.19
Chicken pox recovery time	1.59	1.97	2.55	0.48
Asthma definition	2.69	2.72	.12	0.01
Asthma causality	0.81	0.97	.82	0.17
Asthma incubation time	0.22	0.09	.89	-0.24
Asthma recovery	1.44	1.66	1.27	0.23
Asthma recovery time	1.28	1.19	-.50	-0.08
Toothache definition	2.91	3.09	.77	0.17
Toothache causality	1.56	1.44	-.84	-0.16
Toothache incubation time	0.75	0.56	-1.00	-0.21
Toothache recovery	1.78	1.91	.78	0.16
Toothache recovery time	1.47	1.53	.37	0.07

* $p < .002$.

Table 5.3: (ii) Group

	Pre-test M	Post-test M	t (31)	Cohen's d
Cold definition	2.78	2.72	-.39	-0.07
Cold causality	1.56	1.78	1.32	0.22
Cold incubation time	1.22	1.47	1.19	0.23
Cold recovery	1.91	2.09	1.10	0.26
Cold recovery time	1.63	2.03	2.14	0.51
Chicken pox definition	2.59	2.69	.50	0.08
Chicken pox causality	0.81	1.38	3.14	0.64
Chicken pox incubation time	0.63	1.06	1.72	0.39
Chicken pox recovery	1.88	2.16	1.36	0.33
Chicken pox recovery time	1.47	1.81	1.88	0.40
Asthma definition	2.41	3.00	1.91	0.37
Asthma causality	0.81	0.94	.78	0.15
Asthma incubation time	0.34	0.19	-1.22	-0.22
Asthma recovery	1.22	1.66	2.95	0.44
Asthma recovery time	0.63	1.16	2.52	0.57
Toothache definition	2.97	3.16	.81	0.19
Toothache causality	1.56	1.56	0	0
Toothache incubation time	0.75	0.78	.16	0.03
Toothache recovery	2.06	2.03	-.19	-0.04
Toothache recovery time	1.72	1.69	-.22	-0.04

*$p < .002$.

The group alone condition (see Table 5.3 (ii)) did not reveal any significant pre- to post-test improvement for the contagious illnesses. Again, little positive change was observed for the non-contagious illnesses.

Table 5.3: (iii) Individual + explanations

	Pre-test M	Post-test M	t (31)	Cohen's d
Cold definition	2.97	2.91	-.30	-0.07
Cold causality	1.31	2.09	3.73*	0.79
Cold incubation time	0.72	1.38	2.95	0.54
Cold recovery	1.81	2.25	2.95	0.64
Cold recovery time	1.50	1.88	2.04	0.45
Chicken pox definition	2.69	2.72	.15	0.02
Chicken pox causality	0.81	1.44	2.98	0.59
Chicken pox incubation time	0.41	1.00	2.46	0.54
Chicken pox recovery	1.66	2.22	3.14	0.64
Chicken pox recovery time	1.25	1.81	3.36	0.71
Asthma definition	2.41	2.88	1.77	0.28
Asthma causality	0.78	0.91	.78	0.13
Asthma incubation time	0.13	0.38	1.43	0.38
Asthma recovery	1.59	1.69	.50	0.11
Asthma recovery time	0.94	1.16	1.42	0.20
Toothache definition	2.78	2.78	0	0
Toothache causality	1.19	1.31	.70	0.16
Toothache incubation time	0.50	0.72	1.36	0.24
Toothache recovery	2.00	1.97	-.18	-0.03
Toothache recovery time	1.50	1.69	1.18	0.23

* $p < .002$.

For the individual condition, shown in Table 5.3 (iii), the only contagious illness item that improved significantly was cold causality. However, the data show that there was improvement from pre- to post-test although not significant. There were no significant differences for the non-contagious illness items.

Analyses so far suggest that the effects of the intervention did not generalise to non-contagious illnesses, i.e. there was no pre- to post-test improvement observed for asthma or toothache. However, it is also important to establish whether there was any generalisation across the contagious illness. This was done by comparing correlations between the two contagious illness at pre-test and at post-test. At pre-test, this correlation was $r = .43$, $p < .001$ and at post-test it was $r = .50$, $p < .001$. This increased correlation indicates that there is likely to be some degree of generalisability across the contagious illnesses as a result of the interventions, as understanding of the two illnesses has become more correlated and therefore more similar.

Table 5.4: Mean in-task explanation scores by intervention condition and age group (standard deviation)

		Group + explns	Group	Individual + explns
Cold:	**7 y**	5.25 (1.34)	3.75 (1.12)	4.62 (0.81)
	11 y	8.5 (2.68)	7.25 (2.46)	9.43 (3.52)
C pox:	**7 y**	4.25 (1.84)	4.50 (0.89)	5.00 (0.82)
	11 y	10.50 (3.76)	6.75 (1.84)	7.38 (2.06)

Scores given to explanations generated during the intervention tasks are displayed in Table 5.4, Figure 5.4 and Figure 5.5. These were investigated using a three-way (illness type x intervention condition x age group) ANOVA. There was a main effect of age group ($F(1, 90) = 97.19$, $p < .001$, $f = 1.04$), with 11 year olds giving higher level explanations than the 7 year olds. There was also a main effect of intervention condition (F (2, 90) = 5.87, p < .005, f = 0.36), with children in the group + explanations condition showing higher means then the group condition (p < .005).

Figure 5.4: Mean in-task explanation scores by age group

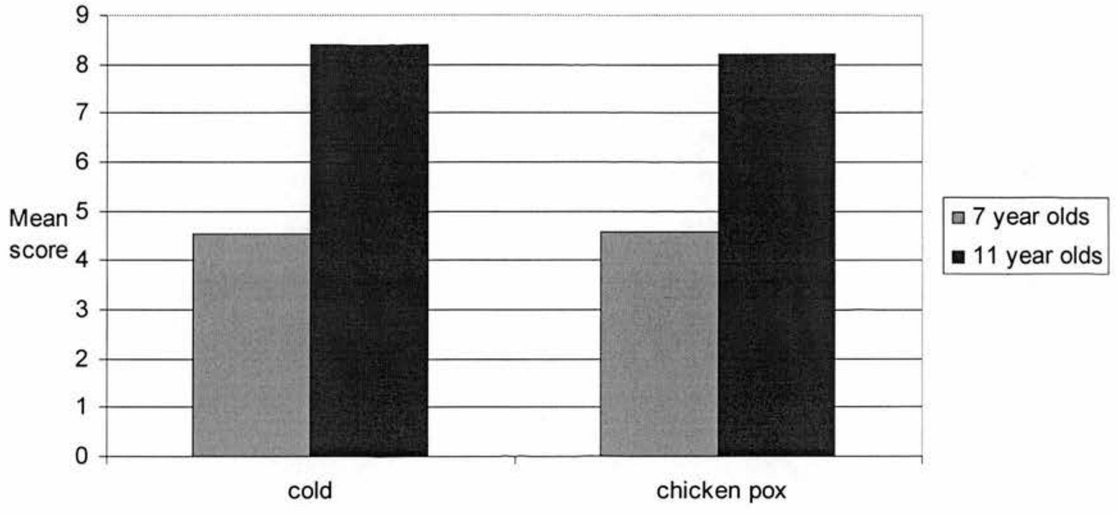
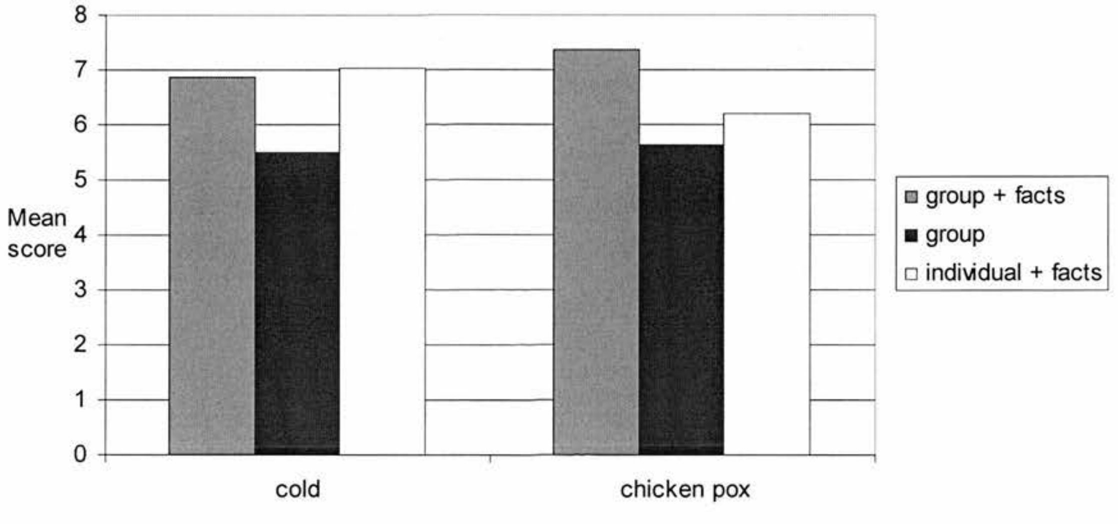
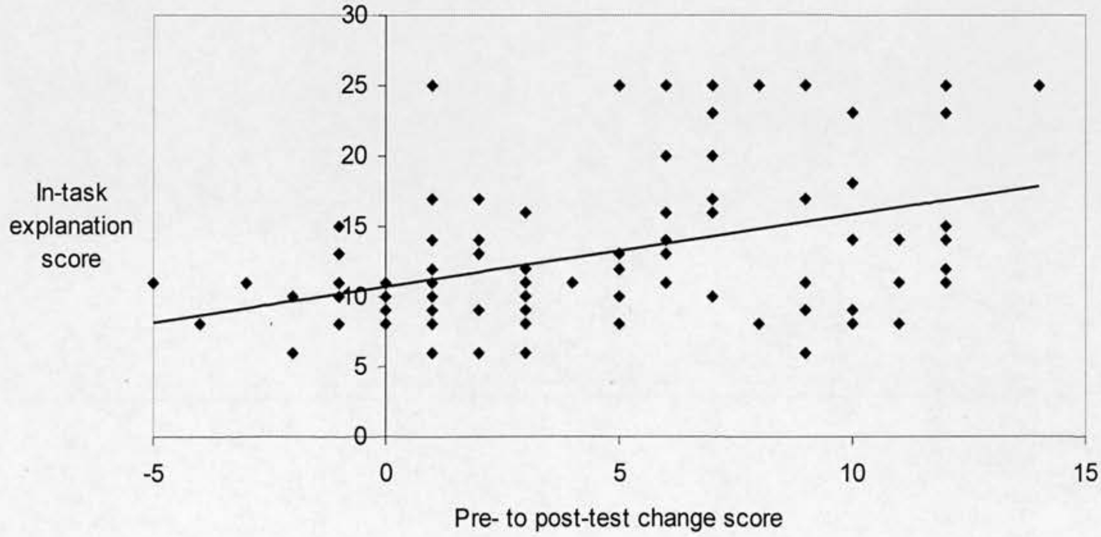


Figure 5.5: Mean in-task explanation scores by intervention condition



The in-task explanations were correlated with pre- to post-test change as shown in Figure 5.6. Here, the in-task explanation scores for cold and chicken pox are added together to give a total explanation score. This collapsing of scores is justified by the high correlation observed between cold and chicken pox scores ($r = .65$, $p < .001$). This total in-task explanation score was significantly correlated with pre- to post- test change for cold and chicken pox ($r = .40$, $p < .001$) indicating that higher explanation scores were related to greater pre- to post-test change overall.

Figure 5.6: Mean in-task explanation scores correlated by pre- to post-test change scores for cold and chicken pox



Correlations between in-task explanation scores and change scores were also calculated within intervention conditions. For each intervention condition, the correlation was found to be significant: group + explanations condition, $r = .36$, $p < .05$; group condition, $r = .35$, $p < .05$; individual condition, $r = .37$, $p < .05$.

5.5. Discussion

This study considered the effectiveness of group discussion and factual information, in the form of explanations, as interventions to improve understanding of illness. It was predicted, on the basis of previous research, that the group discussion and explanations would lead to the highest levels of performance and that peer group discussion alone would prove more successful than the provision of factual knowledge. However, these predictions were not supported by the data and the explanations and group discussion were found to be equally efficacious. The following discussion will firstly consider the pre-test results and then examine the intervention findings in depth.

The results from the pre-test show that the 11 year olds possess greater knowledge than the 7 year olds of all illnesses. This reiterates the finding from Study 1 and supports previous research alluding to a developmental progression in understanding of illness (Charman & Chandiramani, 1995; Hergenrather & Rabonowitz, 1991). The data also show clearly delineated cross-illness differences similar to those found in Study 1, e.g. children showed a better understanding of contagious illnesses than a non contagious illness (asthma). This supports the idea that contagious and non-contagious illnesses are understood in different ways as suggested by Williams and Binnie (2002) and the findings of Study 1. However, the low mean scores, across all illnesses, suggest that there is scope for any intervention to improve understanding.

For all intervention types, the level of pre- to post-test change for every illness was relatively low. There were clear knowledge gains observed for cold and chicken pox but similar improvements were not found for asthma and toothache. This is in line with the finding reported from Study 1 that children have different levels of knowledge of contagious illnesses and non-contagious illnesses. It also adheres to the suggestion that children may have a theory of contagious illness, as proposed by Study 1, Williams and Binnie (2002) and Kalish (1999) that they can build on as a result of the interventions. This is supported by the finding that understanding of cold and chicken pox became more correlated as a result of the interventions, indicating that the children did not just learn directly from the intervention in specific areas. However, it is possible that asthma and toothache are understood in a different way and the effects of the interventions do not generalise to non-contagious illnesses. In addition, some elements of illness might be more difficult to learn than others.

A second trend in the intervention findings was that the 11 year olds improved more as a function of the interventions than the 7 year olds. There are two possible explanations for this: one relating to the intervention tasks and the second a consequence of baseline biology knowledge. Firstly, the age trend could be explained by the increased intersubjective awareness among older children that is suggested by Tomasello et al. (1993) to be necessary for effective group discussion. However, the age effect also holds for the individual condition where increased intersubjective awareness would not play a part suggesting that intervention processes are not solely responsible for older children's higher performance. Alternatively, it is possible that these results indicate a greater readiness to learn about illness at 11 years compared to 7 years. This readiness may be due to greater pre-test knowledge in the 11 year olds that would give more congruent naïve knowledge for the formal knowledge provided by the interventions to interact with and build upon. In support of this suggestion, Sigelman et al. (2003) found that children with greater biological knowledge showed more improvement as a function of an intervention in understanding of drug action.

Unexpectedly, there was little to discriminate between the impact of the three intervention conditions. The only significant difference was between the group + explanations and the group condition with the group + explanations condition having significantly greater change scores for understanding of cold. This difference is corroborated by the global change patterns which show least significance in the group alone condition and also the in-task measures which are significantly lower in this condition than the group + explanations condition. Chapter 3 showed that there is an established literature on the benefits of collaborative learning in both biology (Hatano & Inagaki, 1997; Lumpe & Stave, 1995; Williams & Binnie, 2002; Williams & Tolmie, 2000) and physics (Howe, et al., 1990; Howe, et al., 1992). While the present study confirms the utility of collaborative learning approaches for illness concepts, it differs from other research in that factual knowledge was also productive in leading to conceptual advancement.

Previous research on the importance of factual information in the area of biology has led to inconsistent findings. However, the present study has found that explanations are effective in enhancing knowledge of illness, despite the previous study in this thesis having established that children's understanding of illness is not congruent with formal knowledge . What is it about the factual information in this study which makes it so effective when other studies have found that factual information has little impact on learning?

The factual information provided in this study included not only illness outcomes but also the biological mechanisms underlying these for a range of illness processes. Previous studies have not provided children with this level of biological explanation. It is unlikely that this level of information would have been lower than the children's existing knowledge which may have been the case in the Williams and Affleck (1999) study. Furthermore, the biological mechanisms in the stories were shown to govern all illness processes across two contagious illnesses and this may have helped children develop a more coherent/integrated understanding of germ mechanisms. This is supported by the lack of impact of the interventions on understanding of non-contagious illness. Additionally, the tasks in the present study required children to relate the factual knowledge regarding biological mechanisms to their own ideas, whereas in other studies children have been passively read a story (Springer, 1995; Williams & Affleck, 1999). Both the provision of explanations and the combination of these explanations with different tasks have helped promote engagement with the explanations. The idea that both factual information conditions promoted engagement with the tasks is supported by the higher levels of in-task performance in these two conditions when compared to the group condition showing greater effort being put into the tasks during the intervention.

The cognitive processes underlying the learning from the explanations are not clear. It is not likely that children are learning through rote memorisation because of the time delay between the intervention and post-test, although it is possible as generalisability of knowledge to non-target illnesses was not found. It seems more likely that the children are engaging in a process of conceptual change as a result of being introduced to germ action. From previous literature, there are three alternative accounts of how this may occur. One possibility is that children are replacing their existing misconceptions about illness with the more formal concepts provided by the factual information as described in Chapter 3. This view is upheld by science educators such as Vosniadou and Brewer (1987). In particular children hold misconceptions about the causality of cold (i.e. they believe it is caused by cold weather) which is reduced at post test. Therefore, it is possible that some sort of replacement of theories is occurring.

Alternatively, a theory building account (see Chapter 1) would suggest that the children have been given key facts about contagion that they were able to causally link into a coherent theory (Gopnik & Meltzoff, 1997; Wellman & Gelman, 1992). For example, in Springer's (1995) study, he argued that children were able to work out the core principles of inheritance from inferring from the taught facts. In the present study providing explanations may have given the children a clearer naïve theoretical framework that causally links the facts into a coherent theory of contagion. Support is provided for this as more sophisticated explanations of contagious processes are given at post test.

Finally, it may be the case that children are undergoing the process of representational redescription as described by Karmiloff-Smith (1992) (see Chapter

1). Given that the in-task measures were higher in the conditions where factual information was provided, the discussion or individual reflection of the explanations given may have led to appropriation of the explanations leading to progression of knowledge. Higher levels of explanations in task were linked with greater pre- to post-test change in the present study suggesting that the content of the factual knowledge led to direct reorganisation of children's explanations during the tasks. This spontaneous internal reorganisation of concepts may have given children the ability to verbalise their thoughts, hence the higher post-test scores. As described in Chapter 1, verbalising thoughts is indication of Explicit-3 representations, thought by Karmiloff-Smith to be the highest level of representation. An important direction for future research would be to identify processes that might underlie conceptual change resulting from factual information. To this end, the next study reported in this thesis will aim to provide further information regarding these processes by investigating factual information as an intervention in more detail. Therefore, this important discussion point will be returned to in Chapters 6 and 7.

On a practical level, the tasks used in this study were easy and quick to administer in a classroom setting and seemed to be enjoyed by the children; they liked the format of the story and enjoyed partaking in both the individual and group activities. However, there are certain drawbacks with this study. Firstly, it is not clear what aspects of the factual information made it successful. It may have been the timing of presentation of facts, or the detailed content of the explanations, or the story-format presentation, or a combination of all three. This point provides the basis for the next study to be reported in this thesis: Study 3 will further examine the impact of the content of the factual information and the story format presentation. Additionally, this investigation will be able to provide more information relating to the processes that factual information engages to lead to improvements in knowledge. Finally, only two contagious illnesses were included in the pre- and post-test of this study, so it is not clear if the interventions teach about more than cold and chicken pox. Indeed, it was found that the effects did not generalise to non-contagious illnesses. In order to see if the effects do indeed generalise, more exemplars of contagious illnesses will be included in the intervention study reported in the next chapter.

5.6. Conclusions

In summary, this chapter has reported the findings of a comparative study of different intervention methods. Both collaborative learning approaches and the provision of age-appropriate factual information in the form of explanations had an impact on children's knowledge of illness. Substantial research effort is already being directed to collaborative learning approaches in science and the cognitive processes involved are becoming relatively well understood. Research now needs to be directed to the importance of factual knowledge where previous research has been more inconsistent. This study has been vital in showing the potential of explanations for improving illness concepts and the next study will build on this finding. In particular Study 3 will focus on the context in which factual information is provided, whether basic facts or explanations are more effective and importantly, what cognitive processes are responsible.

Chapter 6:

Study 3: What Do Children Learn About Biology From Factual Information?

6.1. Introduction

Study 2 raised some interesting points regarding the most effective teaching methods for improving understanding of illness. Contrary to hypothesis, group collaborative learning was not unequivocally the best method for improving understanding of illness. Instead, it was found that the factual information also played a strong role in leading to enhancements in knowledge. This leads this chapter to further question the role of factual information and the processes underlying the progression in knowledge. The aim of the study to be reported in this chapter is to investigate the provision of different types of factual information and measure how effective they are in promoting illness understanding.

As well as the practical benefits of interventions that provide factual information, there is a strong theoretical basis for factual information to be advantageous as alluded to in Chapter 3. However, the results from previous research are contrasting. Springer (1995) conducted a study where age-appropriate facts were provided to pre-schoolers. Children were only given very basic facts about inheritance and from this they were able to draw on their own explanations to lead to increases in conceptual knowledge. However, Williams and Affleck (1999) attempted to replicate this finding in 4 and 7 year olds and found that the factual information did not lead to increases in knowledge. Study 2 adds to these findings by showing the efficacy of factual information for improving children's understanding of contagious illnesses. This research suggests that is unclear how successful factual information interventions are, as some studies report advancements in understanding but other studies do not.

By considering the results of Study 2 in combination with the findings of previous research, possible reasons for the success of factual information in certain studies compared to others become clear. The first point concerns baseline knowledge. Williams and Affleck (1999) report that the children in their study had such high knowledge at pre-test that the intervention was not likely to have taught them anything they did not already know. This indicates the importance of determining baseline knowledge before intervention and identifying possible gaps in knowledge that would benefit from intervention. This can be manipulated by carefully targeting specific age groups for intervention based on their current understanding, an approach taken by Study 2.

Indeed, age itself is a variable that may influence the outcome of intervention studies based on factual information. Study 2 found age differences in the amount of pre- to post-test change observed in 7 and 11 year olds, with the 11 year olds benefiting more than the younger children. However, Springer (1995) used a sample of preschoolers in his study which shows that it may not be the age of the children that is most important, but the appropriateness of the factual information for the chosen age groups.

Another possible reason for the lack of clear findings is that these studies have all promoted different levels of engagement with the task. First, the type of factual information provided may influence levels of change. Springer (1995) gave only basic facts and allowed children to draw on their own explanations. However, children already have a basic understanding of contagion, what they lack is understanding of finer details and how all the illness processes are linked together (see Study 1). In this case, the provision of detailed explanations of biological mechanisms may help children construct a coherent theory of contagion. As well as this, it was concluded in Chapter 5 that by providing explanations, increased engagement with the task led to the observed increases in knowledge. However, this could be further tested by comparing explanations with basic facts.

Second, another possible factor that could lead to increased levels of engagement is the format of the task. In Study 2, it may not have been the explanations that were successful in promoting engagement – it may have been the format of the stories that helped engage the children with the facts. This is another variable that would need to be investigated.

In the discussion of Chapter 5, various reasons for why factual information had been a successful intervention method were raised. Of particular interest were Karmiloff-Smith's theory of Representational Redescription, theories of theory building and notions of conceptual change. No firm conclusion could be drawn about any of these possibilities. Likewise, it is not the purpose of this present study to specifically test or contrast underlying cognitive development processes. The main purpose of this study is to compare different types of factual information but it is hoped that the results will be able to add to the findings of Study 2 in saying something about the learning processes that occurs as a result of factual information.

All these factors can be taken into account to help design effective ways of improving illness concepts through factual information. Study 2 gives a good basis but one potential limitation with Study 2 is that it did not show generalisability of results to non-contagious illnesses and did not investigate generalisability to other contagious illnesses. This indicates that the children may not have learned anything further from the information than about the target illnesses which shows that they may just be rote learning the facts. Alternatively, it may lend support to the idea that children's understanding of illness is fragmented and they understand different illness types in different ways. To test these conjectures, it is necessary to investigate whether the effects of the interventions are also observed in other contagious illnesses. A further way to test this would be to look at a novel situation where children would not be able to draw upon concrete facts to explain such an illness.

6.2. The Present Study

From Study 2, there is evidence that the provision of facts may be a useful intervention method for improving understanding of illness. However, it is not clear what level of factual information is needed and what the best format of presentation is. For this reason, the aim of the present study was to further investigate the efficacy of factual information as an intervention to improve knowledge of illness, using a pre-test - intervention - post-test design. The results from the pre-test will again provide useful information on the structure and content of children's illness concepts.

There were three intervention conditions, differing on the type of factual information provided. One condition included detailed facts about contagious illnesses in the form of an illustrated story. The second condition included the same level of detail but was presented in a more formal scientific style, thus children's engagement with the text is likely to be lessened. Finally, there was a condition which provided basic facts without any explanations in a story format. It is hypothesised that the conditions which provide detailed explanations will show significantly greater improvement than the condition with basic facts and that the story style will lead to more improvement than the scientific style because the children should be able to relate to the story format.

6.3. Method

6.3.1. Participants

Children from two age groups: seven years (N = 48, 26 boys, 22 girls: M = 7,5; range = 7,2 to 8,0) and eleven years (N = 48, 24 boys, 24 girls: M = 11,4; range = 11,0 to 11,11) participated in this study. Children were recruited through the same processes described in Chapter 4. The majority of the sample were white Caucasian (N=90), the remainder were Asian.

Social background

Using free school meal entitlement as an indicator of deprivation, two of the schools visited in this study were high SES, and two were mid SES.

6.3.2. Materials

Pre-test/Post-test

The interview schedule for the pre-/post-test contained questions relating to four contagious illnesses. Cold and chicken pox were included as in Study 2 and two other contagious illnesses were chosen to determine if the effects of the intervention would generalise. The first was tonsillitis which had been included in the pilot study of Study 1. Children had shown an understanding of what this ailment was but did not speak on it to the same length as cold and chicken pox. The second illness included was a "created" illness which would be novel to the children. This would attempt to stretch children's knowledge by assessing the degree to which they appropriately generalise principles of contagion to this new situation. This method of introducing a novel situation to assess conceptual understanding has been used in research on living kinds (Carey, 1985), and illness (Keil et al., 1999).

As in previous studies, each illness was introduced by a vignette describing a child character displaying symptoms of the illness. The questions about each illness which followed the vignettes were the same as Study 2. The following example shows the outline of the questions, using the created illness, mosilitis as an exemplar.

This is Amy. She has yellow skin and a rash on her face. She is also coughing and sneezing a lot. This is because she has mosilitis.

Definition: Can you tell me what mosilitis is like?

Causality: How do you think Amy got mosilitis?/ Why would that make her get mosilitis?

Incubation time course: How long after getting mosilitis would Amy start to feel bad?/ Why would it take that long?

Recovery: Could Amy do anything to make herself feel better?/ Why would that make Amy feel better?

Recovery time course: How long would it take for Amy to feel better?/Why would it take that long?

Full details of the pre-test/post-test are included in Appendix I.

Intervention

As in Study 2, there were three intervention conditions. These were all individual tasks and differed in the type of factual information that they included. See below for descriptions of the different types of factual materials. The materials in this study were based on those used in Study 2. Each condition started with the same series of questions about cold and chicken pox and children were required to indicate their answers on fixed choice response cards (see Appendix III). The tasks also used two specially designed booklets (one for cold and one for chicken pox) which provided information in sequence about causality, incubation time course, recovery strategies and recovery time course. Specific instructions were given which led the children through each of their response cards on the illness processes. For example, the first item in each booklet was causality and the children were asked to think about their answers and indicate whether they still thought their answer was right. They were then asked to think of a reason and write it down in the booklet. The relevant parts of the story were included throughout the task as in Study 2. Direct feedback of the correct answers was also given in the booklet, by showing the children a response card with the correct answer ticked.

The three conditions are outlined below:

Story + explanations: The facts in this condition were given in a storybook style. It involved a child character who contracted either cold or chicken pox and described each stage of the illness with reference to the biological mechanism. For example, when explaining why it would take some time between contracting an illness and starting to feel ill, this story provided detailed descriptions of the viruses multiplying and the effect on the human body. An example of this factual information is in Appendix IV.

Story + no explanations: This condition also included the facts in a storybook format. However, no details of biological mechanisms were given. Instead more emphasis was placed on the basic facts. This condition was based upon Springer (1995) who argued that providing basic facts would be enough to build a theory (example in Appendix IV).

Scientific factual: The facts in this condition were presented in a more formal scientific style with no child characters. The same level of detail was included as in Story + explanation with detailed explanations of biological mechanisms given. The purpose of this condition is to examine the level of engagement with the materials (example in Appendix IV).

6.3.3. Procedure

Pre-test

Children were taken out of class individually and asked the questions on each illness. These interviews lasted around 10 minutes.

Intervention

The children in each age group were placed at random by picking names out of the class lists, into one of the three intervention conditions. There were equal numbers of children from each age group in each condition. The interventions took place one week after the pre-tests.

The intervention was held out of class with five children seated round a table. The children were first required to answer the initial questions on cold and chicken pox. The children were then led through the first page of the workbook by the researcher and when they all understood the task; they were left to complete the rest of the workbook and the second workbook, including reading the factual information individually.

Post-test

The post-test used the same materials and procedures as the pre-test. Like Study 2, the post-tests took place six weeks after the intervention.

6.3.4. Coding

Responses from the pre-test, intervention task and post-test were coded using content analysis in line with methods used throughout this thesis. The coding scheme from

Study 2 was used. This was felt to be appropriate as there were only contagious illnesses included in the present study and this was covered by the coding scheme in Study 2. As there was the addition of the created illness, inter-judge reliabilities for each question were re-calculated and ranged from 84% 92%. The coding scheme can be found in Appendix V.

6.4. Results

The data from this study were gathered and analysed in a similar way to Study 2 (see Chapter 5). It was judged to be suitable for parametric testing and the data were analysed accordingly. Again, scores for each illness were collapsed to provide a single score for each illness. The pre-test results were analysed using illness type (cold, chicken pox, tonsillitis, mosilitis) x intervention condition (explanation, scientific facts, no explanation) x age group (7 years, 11 years) three-way ANOVAs. Any main effects were then examined by use of post hoc t-tests with corrections for the significance values or post hoc Tukeys. Interaction effects were explored with the use of one-way ANOVAs and post hoc Tukeys. The same procedures were applied to the pre- to post-test change scores in order to measure the effects of the interventions and also the in-task explanation scores. One-sample t-test were used to establish whether change was significantly different from zero overall. Additional analyses in the form of a series of t-tests investigated the illness processes in more detail. Effect sizes reported are Cohen's d for t-tests and Cohen's f for ANOVAs (Cohen, 1988).

The pre-test scores are shown in Table 6.1 and Figure 6.1. A three-way (illness type x intervention condition x age group) ANOVA found a main effect of illness ($F(3, 270) = 84.26$, $p < .001$, $f = 0.97$). Post hoc t-tests with Bonferroni corrections showed that mosilitis had significantly lower pre-test score than the other three illnesses and tonsillitis had lower scores than cold and chicken pox (all ps $< .001$). There was also a main effect of age group ($F(1, 90) = 24.99$, $p < .001$, $f = 0.53$), with the 11 year olds scoring higher than the 7 year olds. There were no differences detected between the intervention conditions at pre-test.

Figure 6.1: Mean pre-test scores by age group

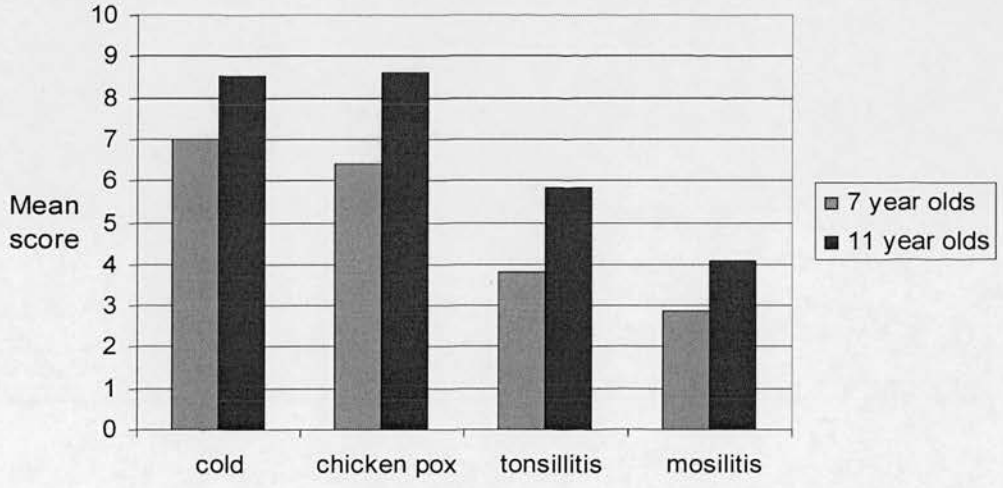


Table 6.1: Mean pre- and post-test scores by intervention condition and age group (standard deviation)

		Pre-test			Post-test		
		Explanation	**Scientific Facts**	**No explanation**	**Explanation**	**Scientific Facts**	**No explanation**
Cold:	**7 y**	7.12 (2.42)	6.12 (2.16)	7.68 (2.30)	9.31 (2.80)	7.50 (2.78)	8.13 (2.63)
	11 y	8.13 (2.68)	8.75 (1.39)	8.69 (2.15)	11.81 (2.46)	11.13 (2.19)	9.88 (1.78)
C pox:	**7 y**	6.85 (2.10)	5.56 (2.53)	6.87 (1.67)	8.25 (1.57)	7.31 (1.89)	7.94 (1.44)
	11 y	8.19 (2.64)	8.69 (2.65)	8.94 (2.21)	10.94 (2.14)	11.75 (2.46)	9.81 (2.26)
Tonsillitis:	**7 y**	4.75 (3.17)	3.00 (2.87)	3.68 (3.05)	5.56 (3.65)	4.06 (3.21)	4.63 (3.52)
	11 y	5.13 (2.92)	6.31 (3.03)	6.06 (2.74)	7.81 (3.33)	8.00 (3.69)	7.06 (2.41)
Mosilitis:	**7 y**	2.88 (2.60)	2.63 (2.47)	3.06 (2.54)	3.94 (3.36)	3.19 (2.83)	3.69 (2.65)
	11 y	4.81 (2.74)	3.37 (3.03)	4.00 (2.94)	7.38 (4.13)	8.06 (3.68)	5.94 (1.91)

Figure 6.2: Mean pre- to post-test change scores by age group

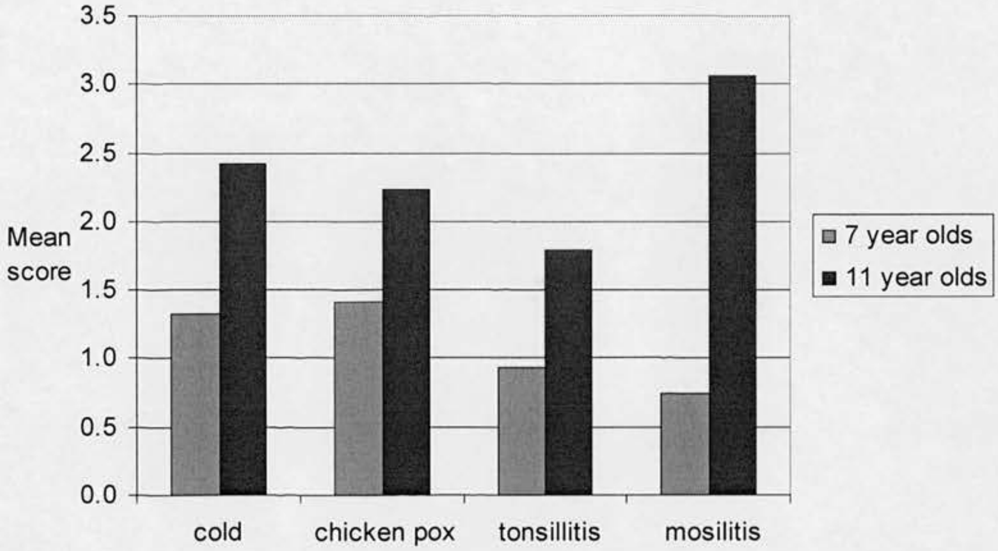
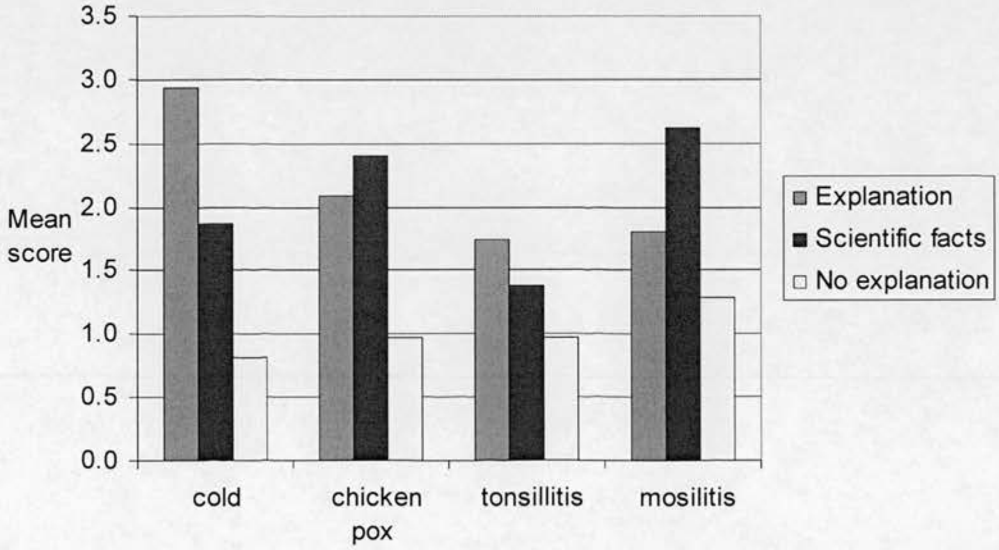


Figure 6.3: Mean pre- to post-test change scores by intervention condition



Using the same procedure as Study 2, pre-test scores were subtracted from the post-test scores to give a measure of pre- to post-test change. First, it is important to determine whether these change scores are significantly different from zero overall.

Therefore one-sample t-tests were used to compare mean change to zero and the results are shown in table 6.2. As can be seen, change was significantly different from zero for all illness in the explanation and scientific facts condition. It was also significantly different for chicken pox and mosilitis in the no explanation condition.

Table 6.2: One sample t-tests comparing mean change to zero

Illness	Intervention	Mean change	t-value
Cold	Explanation	2.94	6.18**
	Scientific facts	1.87	3.82**
	No explanation	0.81	1.59
Chicken pox	Explanation	2.09	4.20**
	Scientific facts	2.41	5.00**
	No explanation	0.97	2.21*
Tonsillitis	Explanation	1.75	3.47*
	Scientific facts	1.37	2.69*
	No explanation	0.97	1.53
Mosilitis	Explanation	1.81	2.86*
	Scientific facts	2.63	4.24**
	No explanation	1.28	2.10*

**p<.001; *p<.05

A three-way (illness type x intervention condition x age group) ANOVA was utilised which found no differences in change scores between the illnesses. There was a main effect of age group ($F(1, 90) = 12.46$, $p < .001$ $f = 0.37$), with the 11 year olds showing significantly greater change scores than the 7 year olds, and a main effect of intervention condition ($F(2, 90) = 4.21$, $p < .05$, $f = 0.30$). Post hoc Tukey tests determined that the explanation condition and the scientific facts condition showed greater change scores than the no explanation condition (all $ps < .05$). No interaction effects were found.

Tables 6.3 (i), (ii) and (iii) break down each illness into the different components to show which aspects improved as a result of intervention. It can be seen that, with few exceptions, each illness aspect shows improvement from pre- to post-test. T-tests compared the post-test scores with the pre-test scores. As multiple t-tests were conducted on these data, Bonferroni corrections were used to alter the p value. Therefore, results are reported as significant where $p < .002$.

Across intervention conditions, no one illness process was found to be consistently significant, indicating that any illness process can improve significantly from pre- to post-test. The intervention conditions being considered separately provides further support for the finding that the no explanation condition was not as successful at facilitating knowledge as the other conditions. This is demonstrated as there were more instances of significant post-test improvement in the explanation and scientific facts conditions.

Table 6.3: Mean scores at pre- and post-test for each illness item by intervention condition

(i) Explanation condition

	Pre-test M	Post-test M	t (31)	Cohen's d
Cold definition	2.69	2.94	1.68	.33
Cold causality	1.47	2.31	3.37	.81
Cold incubation time	0.47	1.19	3.47	.70
Cold recovery	1.44	2.13	4.53*	1.04
Cold recovery time	1.56	2.00	3.26	.68
Chicken pox definition	2.75	3.00	1.35	.37
Chicken pox causality	1.25	1.69	2.82	.42
Chicken pox incubation time	0.31	1.03	3.01	.69
Chicken pox recovery	1.44	1.88	2.82	.66
Chicken pox recovery time	1.75	2.00	1.76	.44
Tonsillitis definition	2.06	2.19	0.57	.09
Tonsillitis causality	0.59	1.09	3.71*	.67
Tonsillitis incubation time	0.13	0.34	1.56	.14
Tonsillitis recovery	1.25	1.63	2.55	.42
Tonsillitis recovery time	0.91	1.44	2.79	.56
Mosilitis definition	0.75	1.53	3.57*	.57
Mosilitis causality	1.03	1.13	0.50	.12
Mosilitis incubation time	0.06	0.41	2.61	.57
Mosilitis recovery	1.13	1.44	1.67	.32
Mosilitis recovery time	0.88	1.16	1.25	.27

* $p < .002$.

Table 6.3 (i) shows that there is some significant improvement from pre- to post-test in the explanation condition for all illnesses.

Table 6.3 (ii) Scientific facts condition

	Pre-test M	Post-test M	t (31)	Cohen's d
Cold definition	2.63	2.47	-0.93	-.18
Cold causality	1.22	2.03	4.94*	.88
Cold incubation time	0.38	1.09	3.13	.74
Cold recovery	1.81	1.78	0.19	.05
Cold recovery time	1.41	1.94	3.57*	.70
Chicken pox definition	2.69	2.91	1.02	.23
Chicken pox causality	1.19	1.72	2.72	.42
Chicken pox incubation time	0.44	1.00	2.29	.45
Chicken pox recovery	1.69	2.00	2.26	.47
Chicken pox recovery time	1.13	1.91	4.02*	.97
Tonsillitis definition	1.72	2.03	1.57	.21
Tonsillitis causality	0.72	1.03	1.38	.32
Tonsillitis incubation time	0.25	0.16	-0.90	-.18
Tonsillitis recovery	1.28	1.53	1.11	.24
Tonsillitis recovery time	0.69	1.28	2.89*	.60
Mosilitis definition	0.53	1.50	3.52*	.72
Mosilitis causality	0.69	1.34	4.29	.60
Mosilitis incubation time	0.16	0.34	1.18	.28
Mosilitis recovery	1.06	1.44	1.61	.39
Mosilitis recovery time	0.56	1.00	2.03	.46

* $p < .002$.

Likewise, Table 6.3 (ii) shows that there are some significant improvements in the scientific facts condition.

Table 6.3 (iii) No explanation condition

	Pre-test M	Post-test M	t (31)	Cohen's d
Cold definition	2.91	2.91	0	0
Cold causality	1.59	1.63	0.19	.04
Cold incubation time	0.59	0.69	0.36	.09
Cold recovery	1.50	1.97	2.79	.77
Cold recovery time	1.59	1.81	1.87	.29
Chicken pox definition	3.00	2.84	-1.09	-.25
Chicken pox causality	1.19	1.53	1.48	.29
Chicken pox incubation time	0.31	1.03	3.01	.69
Chicken pox recovery	1.59	2.00	2.43	.66
Chicken pox recovery time	1.84	1.97	1.00	.26
Tonsillitis definition	1.94	2.03	0.36	.06
Tonsillitis causality	0.59	0.84	1.48	.32
Tonsillitis incubation time	0.06	0.06	0	0
Tonsillitis recovery	1.38	1.47	0.50	.10
Tonsillitis recovery time	0.91	1.44	2.42	.55
Mosilitis definition	0.78	1.03	0.86	.18
Mosilitis causality	0.88	1.22	2.47	.44
Mosilitis incubation time	0.02	0.13	1.14	.31
Mosilitis recovery	1.00	1.16	0.79	.17
Mosilitis recovery time	0.84	1.28	1.75	.46

* $p < .002$.

The above table shows that there is no significant pre- to post-test improvement within the no explanation condition.

From these analyses, it appears as though there is some degree of generalisability of the interventions. The ANOVA analysis indicated that there were no significant differences between the change scores for the four illnesses, suggesting that improvements in understanding occurred at a similar level for all the illnesses. To further investigate this, a series of correlations were carried out, the idea being that if the correlation between two illnesses was higher at post-test than pre-test, then the understanding of the illnesses was further related. Table 6.4 below shows the correlations between the four illnesses at pre- and post-test. Most of these correlations are higher at post-test with the exception of cold – tonsillitis and chicken pox – tonsillitis which are lower.

Table 6.4: Correlations between the illnesses at pre- and post-test

	Pre-test r	Post-test r
Cold – chicken pox	0.40**	0.32**
Cold – tonsillitis	0.30**	0.44**
Cold – mosilitis	0.39**	0.46**
Chicken pox – tonsillitis	0.33**	0.30**
Chicken pox – mosilitis	0.27*	0.47**
Tonsillitis - mosilitis	0.32**	0.59**

** $p < .001$; * $p < .01$

Table 6.5: Mean in-task explanation scores for each illness type by intervention condition and age group (standard deviations)

		Explanation	Scientific	No Explanation
Cold:	**7 y**	4.00 (1.67)	3.63 (1.36)	3.31 (1.78)
	11 y	8.94 (2.95)	9.38 (2.15)	7.68 (2.82)
C pox:	**7 y**	2.25 (2.17)	1.19 (1.55)	0.75 (2.08)
	11 y	9.06 (3.41)	9.13 (3.70)	6.44 (3.03)

The in-task explanation scores (Table 6.5) were investigated by a three-way (illness type x intervention condition x age group) ANOVA. This found a main effect of illness ($F(1, 90) = 29.30$, $p < .001$, $f = 0.57$), as cold scores were higher than chicken pox scores. The 11 year olds had higher scores than the 7 year olds and this was found to be significant ($F(1, 90) = 176.25$, $p < .001$, $f = 1.40$). There was a main effect of intervention ($F(2, 90) = 4.47$, $p < .05$, $f = 0.31$) and post hoc Tukey tests showed that the explanation condition displayed higher scores than the no explanation condition ($p < .05$). Finally, there was an interaction effect of illness type x age group ($F(1, 90) = 12.83$, $p < .001$, $f = 0.37$). This was investigated through t-tests which found that there was a difference between cold and chicken pox scores in the 7 year olds ($t(47) = 8.37$, $p < .001$, $d = 1.24$) but there was no difference in the 11 year olds.

Figure 6.4: Mean in-task explanation scores by age group

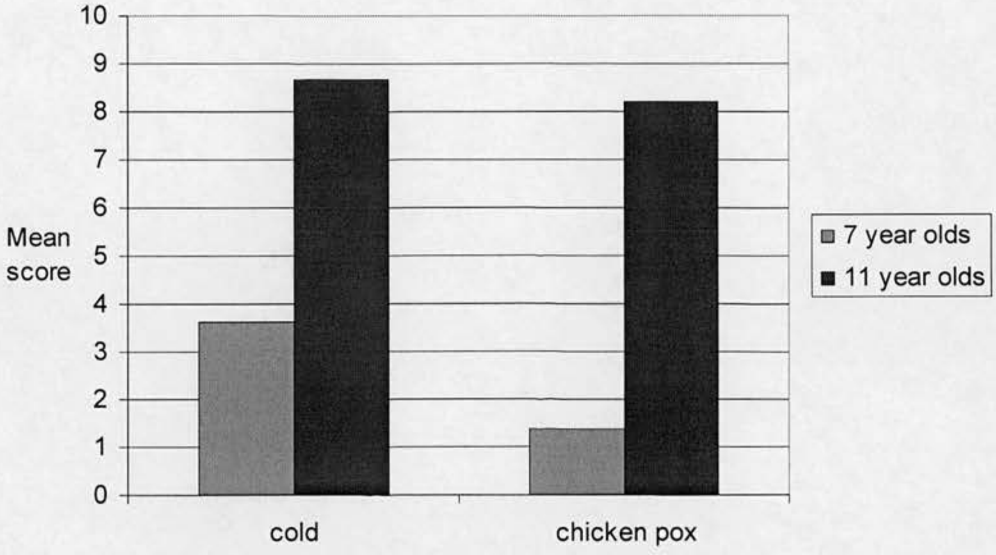
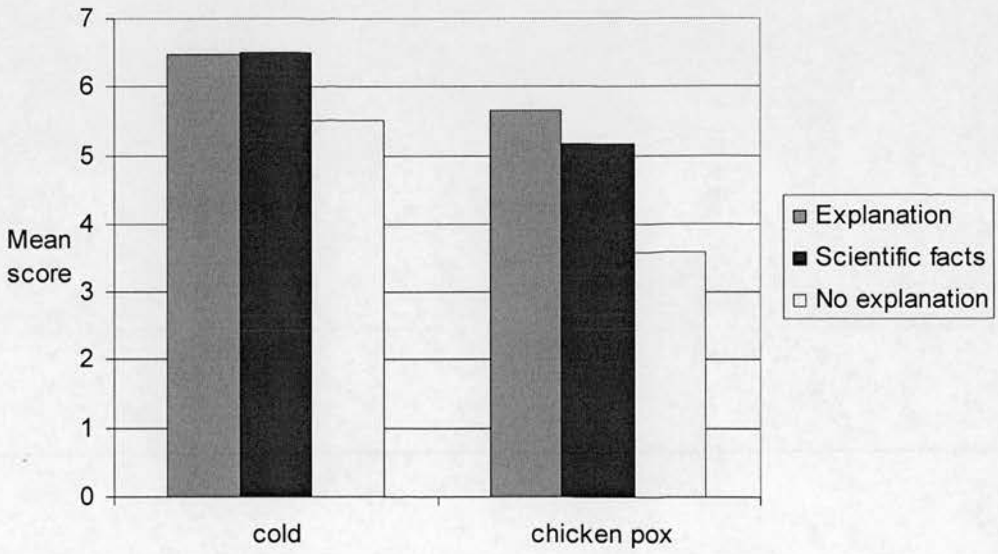
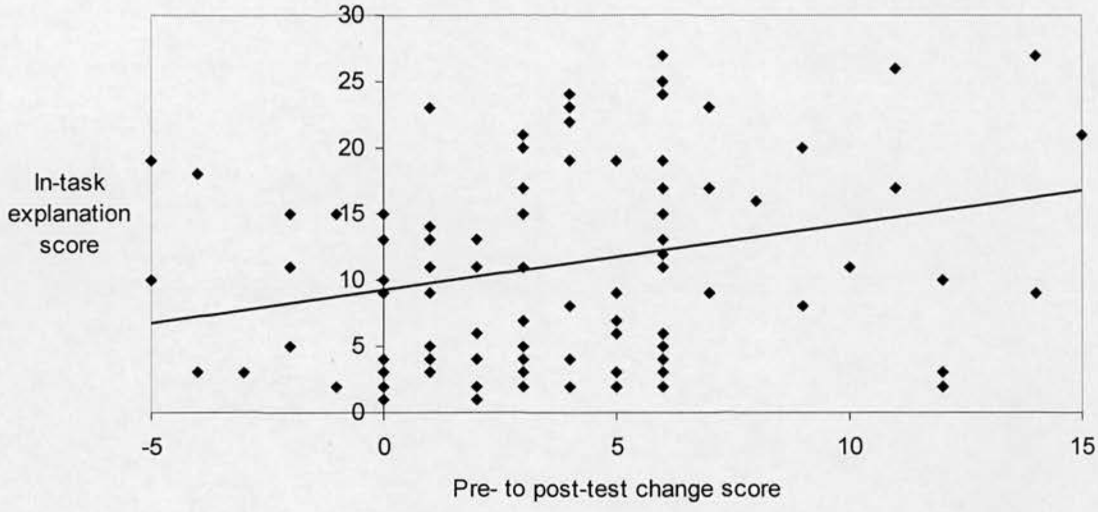


Figure 6.5: Mean in-task explanation scores by intervention condition



The in-task explanation scores were also correlated with the pre- to post-test change scores. This correlation was found to be significant, $r = .28$, $p < .01$. Figure 6.6 shows that higher in task explanation scores indicate higher pre- to post-test change scores.

Figure 6.6: Mean in-task explanation scores correlated by pre- to post-test change scores for cold and chicken pox



Correlations between in-task explanation scores and change scores were also calculated within intervention conditions. For the explanation and scientific facts intervention conditions, the correlations were found to be significant: explanation condition, $r = .51$, $p < .005$; scientific facts, $r = .49$, $p < .005$. The correlation between in-task scores and change scores was not significant within the no explanation condition.

6.5. Discussion

This study has investigated the effect of factual information as an intervention to improve knowledge of illness and provides additional baseline data on children's intuitive illness concepts. Several important findings emerge from the study. The results from the pre-test correspond with the findings described in Chapters 4 and 5 as they show that the 11 year olds have more advanced knowledge of illness than the

7 year olds. In line with the hypotheses, factual information which includes detailed descriptions of mechanisms was significantly more successful than factual information which does not include mechanisms. Surprisingly, there was no difference between an intervention providing information about these mechanisms in a story format and an intervention that presented them in a standard scientific format. Further, the effects of these interventions did appear to generalise to other contagious illnesses. As described in Chapter 5, The 11 year olds in this study also showed greater change than the 7 year olds and higher in-task explanation scores. The following discussion will consider each finding in turn.

The pre- and post-test included two contagious illnesses not included in the intervention tasks: tonsillitis and mosilitis. Despite mosilitis being a novel illness that was created for the purposes of this study, children were able to provide explanations of what it was, how it was caused, time course and recovery factors. However, as expected, understanding of this illness was lower than for other illness. Further discussion of children's understanding of this novel illness will be addressed in Chapter 7 as this adds to debate on how children understand illness. Understanding of tonsillitis was also lower than cold or chicken pox. This was probably due to tonsillitis being a less common illness that the children are not likely to have much experience of.

This study has found strong age differences in understanding of illness. For example, children aged 7 years were able to use biological explanations such as contagion for the illness but the 11 year olds gave much more detailed explanations which included a description of the functions and role of germs. A comparison of these findings with Study 2 shows that the mean scores achieved for each illness are similar. These findings are consistent with the findings from the rest of this thesis and a wide body of previous research that has found development of children's illness concepts (e.g. Charman and Chandiramani, 1995; Hergenrather & Raboniwits, 1991; Koopman et al., 2004).

There was improvement in post-test scores compared to pre-test scores indicating that interventions based on factual information can be successful if teamed with an activity designed to engage children's interest. The no explanation condition was found to show significantly lower mean change scores than the explanation condition and the scientific facts condition. This is backed up by the global change patterns which indicate that there is more pre- to post-test difference in the explanation conditions for most features of the four illnesses. These results support the hypothesis that providing the basic facts about illness outcomes is not enough and children also need to be provided with factual information about the mechanisms to lead to significant changes in knowledge. This result refutes Springer's (1995) claim that facts are important in order to construct a theory of biology (see Chapters 1 and 3) by illustrating which facts are most influential. There were no differences between the scientific facts condition and the explanation condition. This suggests that the level of engagement with the text was similar in the two conditions. This is somewhat surprising, especially amongst the 7 year-olds, and suggests that the content of the factual information rather than the format in which it is delivered is the crucial factor promoting engagement in the task. As in Study 2, in-task performance scores are higher in the explanation and scientific facts conditions further supporting this idea.

It was of interest to identify whether the effects of the interventions would generalise to other illnesses. Study 2 found that there was no generalising effect of an intervention designed to improve knowledge of cold and chicken pox to non-contagious illnesses. It was of interest here to investigate whether understanding of other contagious illnesses would be improved, thus ruling out the possibility that the interventions would only improve knowledge of the target illnesses. The findings of this study are promising as understanding of mosilitis and tonsillitis did improve at a similar rate to cold and chicken pox. This is demonstrated by the lack of significant differences between the change scores for the illnesses and also the global change patterns which also show significantly greater post test scores for many processes of tonsillitis and mosilitis. Furthermore, there is some degree of increased correlation between most of the illnesses between pre- and post-test indicating that knowledge of the contagious illness was becoming more similar.

A further interesting finding of this study was that the 11 year olds showed significantly greater pre- to post-test change scores than the 7 year olds. This was also found by Study 2. No interactions were found although it may have been expected that the different age groups may have benefited more from the different types of facts. Possible reasons for this age difference were discussed in Chapter 5 where it was concluded that the most likely candidate was that the greater biological knowledge in the 11 year olds gives them more to build upon, therefore leading to greater levels of change (Sigelman et al., 2003). This explanation would also be applicable to the present study.

Having determined that factual information which provides detailed explanations is a successful intervention method for improving knowledge of illness, the cognitive processes underlying the learning from the factual information can be considered. Evidence for a shift in knowledge is provided from careful analysis of the post-test responses. For example, more 7 year olds at post-test could explain illness transmission in terms of germ action and detailed contagious processes than at pre-test and this is more marked at 11 years. It was not possible from the results of Study 2 to discount rote learning as no generalisability of the interventions was found. However, in this study illnesses not included in the intervention were found to improve at a similar rate to the target illnesses. This makes it increasingly unlikely that providing children with factual information leads to improvement through rote learning. Further evidence against this is that the post-test was conducted at a delay of six weeks making it unlikely that children would "remember" things at this time lag. Finally, the pre- and post-test were designed to measure the sophistication of children's knowledge rather than how many facts they could report.

It is possible that conceptual change is occurring where children's misconceptions are replaced with more scientific knowledge. The children were made aware if they held misconceptions in this study by asking initial viewpoints that were then clarified. This would lead to the opportunity for their misconceptions to be replaced. However, there are other alternatives from within developmental psychology as discussed in

Chapter 5. One suggestion was that rather than the children's ideas being replaced, they were able to causally link the key facts about contagion that they were given into a coherent theory (Carey, 1985). The results of the present study add support to this proposal by showing that providing children with detailed factual information is more successful than providing only the basic facts. However, the results from this study would also support another possibility; that children are undergoing the process of representational redescription (Karmiloff-Smith, 1992) (see Chapter 5). Higher levels of explanations in task were observed in the explanation conditions than in the no explanation condition. This implies that the content of the factual knowledge was important and providing explanations may have led to appropriation of the explanations leading to progression of knowledge. As described in Chapter 1, this process of representational redescription leads to implicit knowledge becoming more explicit and open to verbal explanation.

6.6. Conclusions

This study has expanded on the findings of Study 2 by further exploring the role of factual information in learning about illness. The main finding to emerge from this study is that providing detailed explanations about illness leads to more dramatic increases in understanding than providing basic facts, regardless of whether the explanations are presented in a story-book style or factual style. Thus the *content* of factual information is more important than the *format.* This is an important finding for health and science education as it indicates that children's knowledge of illness can be improved through the provision of age-appropriate facts about the mechanisms of illness. The validity of the results of Study 1 and Study 2 have also been strengthened as some of the key findings from these studies have been replicated here.

Furthermore, the findings of these studies hold implications for theories of development, biological understanding and learning. The following chapter will draw together the findings of this study and of the two preceding studies to discuss the conclusions and theoretical and practical implications.

Chapter 7:

General Discussion and Conclusions

7.1. Introduction

In order to address the aims of this thesis, the empirical work has first, determined what children of various ages during the primary school years understand about different illnesses and second, examined intervention methods that can improve understanding of illness. It is the purpose of this chapter to draw together the findings of these studies and provide discussion on what this research has contributed to knowledge in the area of naïve theories and biology concepts.

It is expected that the results of this thesis can contribute to three areas of developmental psychology. First, as stated in Chapter 1, there is debate about the nature of children's cognitive development and whether it proceeds in a domain-specific or domain-general manner. Specifically, this thesis has investigated whether children have a specific conceptual system for understanding illness within a broader framework of naïve biology, which is considered a core domain of thought by some theorists (e.g. Wellman & Gelman, 1992). Secondly, the findings of this thesis can contribute to knowledge on children's understanding of illness, the development of this understanding and the structure of children's illness concepts. Finally, this thesis has investigated the impact of factual information and collaborative learning as interventions and can therefore add to knowledge on the best ways to teach about illness.

The current chapter discusses the theoretical implications for each of the research areas outlined above. Various methodological shortcomings and issues that have been identified will then be covered and possible directions for future research are mentioned. Special attention to the implications for practice is to be given as this thesis can inform education in schools as well as in health care settings.

7.2. Children's Biological Knowledge and Concepts of Illness

The first two chapters of this thesis set the research in context by discussing children's naïve thinking about the biological world and their understanding of illness. As discussed, children's understanding of illness is an area of research that has informed theory on cognitive development and Chapter 2 demonstrated the impact of illness concepts on domain-general and domain-specific theories of development. Importantly, it was shown that as understanding of illness is a significant part of children's naïve biology (Siegal & Peterson, 1999), it can inform debate on the nature of children's biological thought. Chapter 1 raised the key debates that surround children's biological understanding: when and how does it emerge, and is it theoretical? Chapter 2 expanded on these issues by focusing in on understanding of illness. This section will discuss what the results of this thesis can add to this literature. Study 1 of this thesis directly investigated the development of children's understanding of illness which has the potential to contribute to this literature but the results of Studies 2 and 3 are also relevant.

To begin, the contribution of the research of this thesis to the domain-general approach to children's illness concepts will be discussed. This approach was heavily criticised in Chapter 2 and has been largely discredited by more recent research

(Eiser, 1989; Siegal, 1988). In the view of this early research, children did not have an understanding of illness processes that conformed to formal knowledge. Instead it was argued that children were likely to use immanent justice and magic as explanations of the causality of illness (Bibace & Walsh, 1981; Kister & Patterson, 1980). The results of this thesis clearly show that children do not base their explanations of illness on immanent justice or magic, although the open ended method used gave them every opportunity to. This finding is also in contrast to the position of Carey (1985) who claimed that children understand biology according to a psychological model, this point will be returned to later in this section. The early research was also dominated by Piaget's stage model of development (e.g. Bibace & Walsh, 1981). The results of Study 1 suggest a developmental progression of illness but this does not correspond with the model proposed by Bibace and Walsh (1981). Instead, in line with recent research, it makes more sense to appeal to theories of domain-specific development. Specifically, older children often explained illness making reference to biological processes. Therefore, the findings of this thesis support the proposal that older children are capable of understanding illness according to biological modes of explanation.

In Chapter 1, it was outlined that within the domain-specific approach to cognitive development, there is little agreement concerning the nature of development. Some theorists, e.g. Atran (1990), Sperber (1994) and Keil (1992), have argued that naïve biology is innate. Most evidence in support of this is focused on preschooler's ability to distinguish between the living and nonliving world. However, Chapter 2 showed that research on illness concepts can also inform this debate (e.g. Kalish, 1999;

Springer & Ruckel, 1992). In the present research, children were asked questions on different types of illnesses, the most relevant to this argument are the contagious illnesses (cold and chicken pox). Children in the youngest age group, 4 years old, were most likely to answer "don't know" to these questions. On first glance, this would appear to indicate that the demands of the task may have been too high. The questions asked were sensitive to young children's abilities, but open ended methods do not allow young children to show their full understanding of a topic as they require a certain amount of verbal ability that is not present in 4 year olds (Siegal et al., 1988). However, some 4 year olds were able to give explanations of illness but few of these explanations referred to biology. Instead, they focused on physical influences of illness such as chicken pox being caught from eating bad chickens or not wearing a scarf. It is the finding of this thesis, therefore, that 4 year olds lack a biological understanding of contagion, thus contradicting the positions of Sperber, Atran and Keil.

To look at the next age group, it is clear that 7 year olds do sometimes refer to contagion in their responses to chicken pox, but their explanations are not accurate. For example, they may say that chicken pox is caught from someone else by standing next to them. This is not the case for children's understanding of the cold as most children adopt a physical mode of explanation. This indicates that even at 7 years, children's knowledge of illness does not necessarily involve biological mechanisms. From this we can conclude that children of age 7 years have some way to go before possessing a fully detailed biological understanding of specific contagious illnesses although they have the beginnings of an understanding of the process of contagion.

Furthermore, it would appear that their knowledge of illness as a whole is fragmented and illness specific. Children had different levels of understanding for the different illnesses in Study 1 and Study 2 and the effects of an intervention to teach about contagious illness did not impact on children's understanding of non-contagious illnesses.

The next theory of the development of children's biological understanding is that of Carey (1985; 1995). She believes that an understanding of biology arises from an understanding of psychology at around 7 years. If children held a psychological model of illness, explanations such as "they got ill because they were sad" would be expected. However, during the course of this thesis, no psychological explanations of illness were spontaneously (or otherwise) given, which contradicts Carey's position. It was also explained in Chapter 2 that there is lack of studies which have found psychological explanations of illness. In fact the only examples given in the chapter were from the earlier domain-general research (e.g. Kister & Patterson, 1980). It has already been discussed in this chapter that the research of this thesis is in contrast to the research from the domain-general perspective. This has implications for Carey's theory of conceptual change as she argues that children's knowledge of biology arises from their understanding of psychology through a process of conceptual change. However, the developmental progression of illness concepts reported in Study 1 would suggest that this is not the case. Furthermore, the intervention studies led to improvements in knowledge but they did not replace psychological explanations with biological ones but enhanced children's knowledge, either by filling gaps in biological knowledge or replacing physical explanations of illness with biological ones.

The final possibility raised in Chapter 1 is that naïve biology emerges from an understanding of naïve physics, as suggested by Au and Romo (1999). Indeed, the results of this thesis suggest that children frequently do use physical explanations of illness before biological ones. To expand on this point, children in younger age groups focus on the physical aspects of biological explanations such as proximity to other people, without giving full biological explanations. This is in full support of Au and Romo and also relates to Kalish's (1999) models of infection, discussed later in this chapter.

Chapter 2 also offered different perspectives on the structure and development of children's illness concepts. There are three main views in the existing literature that were discussed. First of all, Keil (1999) argued that children reason about illness according to a domain of biology, but that this understanding is abstract to begin with. He believes that it becomes more specific throughout development. Secondly, Kalish (1999) proposed that there are a series of models of infection that children hold and pass through, in a way analogous to Piagetian stages. Finally, Williams and Binnie (2002) hold a view that children conceptualise different types of illnesses in different ways.

The accuracy measure included in Study 1, allows some discussion of Keil's ideas of abstract to specific shifts in knowledge. Keil (1994) suggested that young children appeal to general domains of knowledge to explain biological phenomena, without having clear understanding of the specific facts. Therefore, the results which show that children use explanations such as "he caught it off someone else" at age 4 years, becoming more and more frequent at ages 7 and 9, would be taken as suggesting that the children are operating within a domain of biology. Furthermore, these explanations become more accurate and include more specific details in the older age groups lending support to the proposal that knowledge becomes more specific with age. However, whether this proposal is accepted depends mainly on the definition of biological knowledge that is used. Au and Romo (1999) would consider such a response as “he caught it off someone else” as an explanation based on physical proximity and not biological. In the studies of this thesis, responses such as this were coded as indicating a certain degree of basic biological understanding. The results of this thesis support Keil’s proposal in part. The provision of detailed facts was found to increase children’s knowledge in Study 3, indicating that it is knowledge of specifics that is lacking in younger children. However, when considering children’s starting state of biological knowledge, this thesis does not correspond with Keil. It has already been argued in this chapter that children start out with a physical understanding of illness. In contrast, Keil (1992, 1994) claims biological understanding is innate.

Kalish (1999) outlined a series of infection models that are primarily concerned with children’s understanding of contagious illnesses. This is a more detailed proposal of the development of illness concepts than Keil’s theory but adheres to the same idea that children’s knowledge becomes more sophisticated and detailed with age.

However, instead of development being as a result of an abstract to concrete shift in knowledge, Kalish places more importance on conceptual change and educational intervention. The most basic model of infection is the associational model which is analogous to the domain-general approach to illness. Study 1 included 4 year olds in the sample but an open ended questioning method was used that did not allow this age group to respond to their highest capabilities. Therefore, a lack of codeable responses makes it difficult to determine whether children in this age group hold an associational model of infection or a physical model. It is apparent that they did not use biological explanations of illness, although a small proportion did say that contagious illnesses could be caught from other people. A lack of detail in these explanations could either be due to lack of verbal ability or lack of biological knowledge. The 7 year old age group give more detailed explanations. However, they still do not give full biological explanations and this cannot be accounted for by a lack of verbal competence. The breakdown of results from Study 1 shows that the majority of 7 year olds prefer to use physical explanations of colds compared to biological, thus corresponding with Kalish's second model of infection: a physical model. However, as seen in all three studies, by age 11 years, children are able to give biological explanations for the causality of contagious illnesses. This would correspond with Kalish's third and fourth models of biological infection. Again, the findings outlined in this thesis do appear to fit in with these models of infection. However, one key difference is that the work of this thesis has considered a lot more than just causality of contagious illnesses. Kalish's models only account for contagion and therefore do not provide a complete picture of the development of other illness processes.

Given that this thesis has considered a range of illness types and illness processes, these two accounts are not suitable for explaining the development of non-contagious illnesses and injuries. This becomes apparent as one of the most consistent findings from the three studies is that children seem to understand different illness types and even different illnesses according to separate systems of knowledge. In particular, they have a more biological understanding of contagious illnesses than non-contagious illnesses. These findings are important in relation to debates within cognitive development concerning the development of biological thought. They suggest that children's understanding of illness is not coherently organised around a single theory. It is perhaps not even likely to be organised in a way such as that suggested by Williams and Binnie (2002), around three micro-theories relating to contagious illnesses, specific non-contagious illnesses and injuries (see Chapter 2 for a further description) as findings suggest that understanding of illnesses may be even more fragmented than this. Although it is likely that children may develop a single theory of contagion to understand contagious illness, children in this study appeared to understand cold in a different way from chicken pox. This indicates that understanding of contagious illnesses may develop in an illness by illness basis, before coming together into a coherent theory. Also fragmented is children's understanding of non-contagious illnesses where response profiles for the illnesses were very different. This study has also shown that although children may learn about contagion from interventions, the effect of the interventions do not generalise to non-contagious illnesses. More research is required on the range of illnesses children have knowledge of at different ages and how they fit within broader framework theories of biology (Wellman & Gelman, 1992).

Finally, it will be considered whether children's understanding of illness is theoretical or not. As stated in Chapter 1, a theory is a coherent well organised system of beliefs empowered in a causal explanatory framework that allows reasoning about phenomena in a particular domain to take place (Wellman & Gelman, 1992). Therefore, if children have a theory of biology they should be able to offer causal explanations that are relevant and appropriate to biological phenomena. In keeping with this definition, the results of the three empirical studies reported in this thesis demonstrate that children offer explanations based on relevant biological processes for the causality of contagious illnesses. However, it was an important finding in this study that children in the younger age groups explain colds as caused by cold weather and not contagion but show an understanding of contagion in relation to chicken pox. This implies that children may have separate theories for different illnesses and their understanding is fragmented. Coherence is a key element of theory-like understanding and by looking at a range of processes in each study, it is clear that children's understanding becomes linked together in the older age groups. There is also a consistency in older children's explanations that is not always observed in the younger children. For example, they provide details of the causality, time course and recovery of contagious illnesses that is consistent with a theory of germ action. However, this coherence and consistency is sometimes observed in the 7 year olds after intervention, confirming the potential of educational intervention.

As well as contributing to developmental psychology literature on children's understanding of illness, the findings are also relevant within health psychology. One of the main criticisms highlighted with this approach by Chapter 2 was that research did not usually refer to any theoretical background when investigating children's understanding of illness. As a result of this thesis, knowledge of what children understand about different illnesses and the ways in which this is related to theories of development has been advanced. See Chapter 4 for a thorough account of what has been discovered about children's understanding of the different illnesses.

7.3. Intervention Methods to Improve Illness Concepts

Identifying intervention methods that can improve children's understanding of illness has obvious practical implications and also strong theoretical implications. Chapter 3 outlined theoretical reasons why collaborative learning and factual information might be expected to be successful at improving illness concepts and this section considers the results of this thesis in light of this theoretical background.

Previous research has found collaborative learning to improve knowledge of physics concepts and biology concepts (Howe et al., 1992; Williams & Tolmie, 2000). The findings of Study 2 add to this by showing that collaborative learning teamed with factual information improved children's understanding of contagious illnesses. Group discussion alone was not enough to lead to significant increases in knowledge. The direction that this thesis took from this finding was to further investigate the role of factual information. However, a more detailed discussion of collaborative learning is provided here to help identify why it was not as successful as previous research predicts.

Chapter 3 introduced the two main theoretical approaches generally taken towards designing collaborative learning interventions. Piagetian theory states that conflict arising in discussion among group members is important in driving changes in understanding (Piaget, 1932). Alternatively, a Vygotskian perspective is more focused on joint problem solving and shared constructions of knowledge (Vygotsky, 1978). Typically, previous research on improving children's science concepts has been based upon the Piagetian idea of cognitive conflict (e.g. Howe et al., 1992). However, Williams and Tolmie's (2000) study on improving children's inheritance concepts suggested that a different process from socially induced cognitive conflict may be important in groups discussing biology. This is supported by the findings of Study 2 (Chapter 5) where group discussion was found to be no more successful than factual information in improving understanding of illness. One possibility is that there is not as much for children to discuss and disagree over with illness concepts in the way that there is with physics concepts. Therefore, the cognitive conflict was not as effective in improving understanding of illness as it has been in improving other areas of conceptual understanding.

The key question relating to the role of collaborative learning in this thesis is: why did collaborative learning work substantially better with the addition of factual information? The first possibility is that a lack of knowledge could have affected the group's ability to interact productively with each other. By this account, the factual information provided throughout the intervention task would have provided things for the children to talk about. However, the children in Study 2 displayed a reasonable amount of knowledge about illnesses at pre-test and indicated an ability to verbalise their ideas making this unlikely. Another possibility is that children progressed via appropriation of the detailed explanations provided in the factual information. Explanations of such detail would not have been received in the group discussion condition as the children in the group would be unlikely to provide such specific and accurate information during the discussions. By looking at the in task explanations generated for each condition in Study 2, it is clear that children were absorbing some degree of the factual information during the interventions as scores were higher in the condition providing facts. Furthermore, a positive correlation was found between high in-task explanation scores and higher pre- to post-test change scores. This indicates that is possible that children progressed through a process of Representational Redescription as a result of appropriating the explanations. This is reconcilable with results found by Tolmie et al. (2005) investigating different interventions to improve children's road crossing abilities. They report a similar finding where children in a condition involving explanations given by adults improved in their road crossing skills significantly more than children partaking in peer discussion. It is encouraging that other studies have similar findings, making the above possibility of progressing through representational redescription more credible.

Turning now from collaborative learning to factual information, the resounding finding that factual information can be presented as a successful intervention will be discussed. Chapter 3 outlined the theoretical reasons why factual information might be expected to improve knowledge of illness. Firstly, Pines and West (1986) suggested that children's naïve biological knowledge is congruent with formal knowledge indicating that teaching involving cognitive conflict was not needed and that factual information would be enough to improve understanding. However, Study 1 identified that children do not necessarily have congruent knowledge of biology and hold misconceptions about many different aspects of illness. Nevertheless, factual information was still investigated as a possible intervention method.

Secondly, Springer (1995; 1999) argued that providing basic facts would allow children to draw inferences about inheritance processes and help in constructing a biological theory of birth and kinship. However the results of Study 3 showed that the provision of basic facts did not improve understanding thus refuting Springer's position. Therefore, we must consider alternative reasons to explain the positive impact of factual information.

It appears as though the use of explanations in place of just basic facts was a key driving force behind the improvements in knowledge in both studies. This was confirmed in Study 3 where the explanation conditions were significantly better than a condition using basic facts. Explanations are likely to have led to improvements as they are precisely the information that children lack. As a result they would have promoted engagement with the intervention. This was demonstrated by the higher in-task performance in the conditions where explanations were provided.

Chapter 5 alluded to various learning processes that may result in the knowledge changes observed as a result of factual information. One of these was theory building (e.g. Gopnik & Meltzoff, 1997). The factual information provided in Studies 2 and 3 may have filled in gaps in children's concepts of illness and helped to make children's understanding of illness more coherent. In support of this, Study 3 found that when children were provided with the factual knowledge that they lack (i.e. detailed explanations of processes involved in contagious illness) they progressed at a greater rate and their post-test understanding was more sophisticated and detailed than at pre-test.

So far, both the processes of representational redescription and theory building appear to be possibilities for the driving force behind the knowledge improvements observed in the intervention studies. This leaves one final possibility: conceptual change. As discussed this concept has roots both in cognitive development literature (Carey, 1985) and science education (Vosniadou et al., 2001). In terms of cognitive development, Carey (1985) suggested that children's knowledge progressed from psychological to biological through a process of conceptual change. This has already been discounted as children do not appear to ever understand illness in terms of psychology.

From a science education perspective, the factual information serves to make children aware that they hold misconceptions and replace these with formal conceptions. Harking back to research on the structure of illness concepts may help unravel these possibilities. Although it is certainly true that children hold misconceptions of illness; whether the successful interventions in this study served to make them aware of these and give them the correct alternative is not entirely clear. What can be said is that where clear alternatives were given in the form of explanations, more change in knowledge was observed than interventions which either gave no facts or only basic facts.

7.4. Methodological Discussion

There are various methodological issues regarding the empirical approach of this thesis which require discussion. This thesis has adopted a quantitative paradigm to explore children's understanding of illness and this is in line with most of the developmental psychology research in this area (Siegal & Peterson, 1999). However, within health psychology as whole, qualitative approaches are increasingly recognised as valuable for providing more insight into people's health attitudes and beliefs (Marks et al., 2005). There is a lack of qualitative research on children's understanding of illness and this may be because children are perceived as less competent and social than adults, and therefore such rich qualitative data would not be obtained from them. However, Woodgate (2001) has suggested that a qualitative approach may be successful in the study of children's illness experiences as long as it is recognised that conducting qualitative research with children involves different challenges and research techniques than qualitative research with adults. If children's competence, their communication styles and the interviewer-child relationship are properly understood, then there is no reason why qualitative methodology cannot be a useful tool for use with children (Curtin, 2001). Future research could look to utilise this methodology in order to find out more about children's experiences and understanding of illness and health. Despite these positive aspects of qualitative research, a quantitative paradigm was more appropriate in this research as it enabled cross-group comparisons and level of change after interventions could be quantified.

On top of this overarching issue, there are more specific points that should be addressed. First of all, within the quantitative research paradigm there is a choice of two experimental questioning methods for use with children: open ended or fixed choice. This thesis employed open ended questioning methods in all three studies. The main criticism is that young children who are inexperienced in conversation may not be able to respond fully and appropriately to adults' questions (Grice, 1975) and therefore may not disclose the depth of their understanding (Siegal & Petersen, 1999). However, an open-ended method was needed to allow a full examination of the structure and content of children's knowledge. Using forced choice methods would not have provided such valuable data as such methods do not truly capture whether children can adequately understand biology – it is not clear why children chose their answer and indeed even whether they would have arrived at their response at all, had it not been suggested.

A second point for discussion is the range of illnesses used in the three studies. In particular, Study 2 would have benefited from a greater number of illnesses at pre- and post-test to measure the generalisability of the interventions. In addition to including a wider range of illnesses, it may have been useful to collect information on contagion itself e.g. children's understanding of viruses/germs and their function.

There are also issues with the samples used in these studies as they were essentially quite a narrow range of participants. The majority of children who participated in this research came from white families making the sample homogeneous in terms of ethnicity. It may have been more relevant and interesting to conduct these studies with a more ethnically diverse sample. This is especially important considering the cross-cultural differences in illness concepts that have been found by recent research (Raman & Gelman, 2004). It is possible that the use of such a homogeneous sample limits the generalisability of the results. It is argued that results from North American and European research cannot be used to inform health education and practice in different parts of the world such as Asia. Instead, care must be taken to ensure education is based upon an understanding of the health belief systems and cultural values of the target population (Landrine & Klonoff, 1992).

In all studies it would have been useful to investigate other factors than just age that may influence children's understanding of illness. Most importantly, there was no measure of illness experience. Due to time constraints, it was difficult to obtain a reliable measure of illness experience as relying on the children self reporting may not have been accurate. This is exemplified by a small number of children (N = 4) in Study 3 who reported experience of mosilitis (e.g. "I've had that"), the made-up illness. A possible alternative would have been to ask the parents. Having a reliable measure of experience would not only have been interesting in terms of the level of children's understanding, but also how this would interact with the interventions.

In studies 2 and 3, age differences in the effects of the interventions were found, with the 11 year olds showing greater pre- to post-test change than the 7 year olds. Possible reasons for this were suggested but it is also possible that this difference was observed due to the different reading abilities of the 7 and 11 year olds. Study 3, in particular, involved a great amount of reading which some of the 7 year olds may have found difficult, thereby not absorbing as much information from the text. Therefore, this finding must be treated with caution.

7.5. Practical Implications of this Thesis

From a practical perspective, the results outlined in this thesis give a very optimistic message for teaching about illness concepts. The interventions were easy to administer in a classroom and the materials used in this study could be developed by teachers for use in health or science education. This section will first cover the educational implications of the findings of the studies. Subsequently, there are implications for health practice that will be given consideration.

7.5.1. Implications for Education

There are several points that arise from this thesis that hold implications for education. The first point concerns when children are ready to learn about health and illness. Readiness to learn is an important concept in education and is argued to be specific to the topic taught and the method of teaching (Watson, 1996). By providing a detailed account of children's understanding of illness, this thesis can make suggestions of the best point in children's cognitive development to begin teaching about illness. The fact that children as young as 4 years old can talk about illness in an open ended interview situation suggests that biology education could be introduced early in the curriculum. This is distinct from Carey (1985) who assumes that children of this age have no form of biology thus implying that the teaching of biology should be postponed until later in schooling. The results of this thesis have shown that children aged 7 years can benefit from age-appropriate education about illness. As long as care is taken to tailor interventions to the appropriate developmental level, primary school children are in a strong position to benefit from education about biology and health.

The second point that arises from determining that children have intuitive knowledge about illness (even if it is not truly "biological") is that this intuitive knowledge may impact upon any efforts to teach about illness. Indeed, it was found that children have some misconceptions about such things as the causality of cold and the incubation time period of germs and these had to be accounted for in the designing of the interventions. Study 3, in particular, compared a condition where factual information was provided that directly challenged these misconceptions (the explanation condition) with factual information that did not (the no explanation condition). The condition with the challenging factual information was found to lead to greater increases in knowledge. Thus, it is shown how vital it is to consider initial knowledge when designing teaching programmes.

Therefore, the combined findings of the three studies indicate that children are ready and eager to learn about biological phenomena and this opportunity should be realised in the primary school curriculum. The results of Study 2 and Study 3 can help to suggest possible teaching approaches. From Chapter 1, it is clear that there are various different influences on the development of children's biological thought (Inagaki & Hatano, 2002). This suggests that there are different approaches that teaching about biology can take. Firstly, an important part of many theories of the acquisition of a theory of biology is the learning of key facts (Carey, 1985; Inagaki & Hatano, 2002; Springer, 1999) and secondly, allowing children to discuss biology has been shown to be important (Hatano & Inagaki, 1997; Williams & Tolmie, 2000). The findings of this thesis support these ideas fully as both collaborative learning and factual information lead to increases in knowledge. However, factual information seems to have had more of an effect. In particular, Study 3 found that providing detailed explanations in line with the understanding that children lack is particularly effective.

7.5.2. Implications for Health Practice

The implications of this thesis also reach into health care settings. The results are particularly relevant in Scotland and the rest of the United Kingdom where legislation states that "a person under the age of 16 years shall have legal capacity to consent on his own behalf to any surgical, medical, or dental procedure or treatment where, in the opinion of a qualified medical practitioner attending him, he is capable of understanding the nature and possible consequences of the procedure or treatment" (Age of Legal Capacity (Scotland) Act 1991). Rushforth (1999) identified that the growing research literature on children's understanding of illness was linked to this perspective on children's rights and their competence to consent. She argued that in order for children to make informed medical decisions they must display accurate knowledge of illness and it is research such as that of this thesis that is needed to inform this position. Traditionally, children were not seen as capable of understanding explanations of illness as they were cognitively immature (Bibace & Walsh, 1981). Without clear accounts of what children understand about illness, there is a danger that medical practitioners could frequently underestimate older children's capability and overestimate younger children's ability. However, the findings of the three studies in this thesis show firstly, that children are capable of giving reasonably sophisticated explanations of illness and secondly, that children are capable of understanding detailed explanations of specific illnesses as demonstrated in the intervention studies. From this, and in line with the perspective of others (e.g. Au et al., 1999; Kalish, 1996b; Inagaki & Hatano, 2002), it is safe to assume that we can regard children who are taken ill as capable of understanding their illness and necessary treatments.

In terms of how illness should be explained to children, the results of the intervention studies are useful. Firstly, children learnt more from detailed explanations of illness making this a more effective way of explaining illnesses than providing only basic facts that practitioners may believe are commensurate with children's level of understanding. Secondly, group discussions with other children were found to be beneficial in combination with accurate facts. Therefore, letting children discuss their illness with other children can be advantageous, if they have the necessary factual information to hand. In this thesis, discussion with others was used as a tool to enhance conceptual understanding of illness and there were no differences found between children in an individual condition compared to a group condition. However, there may be other benefits observed in letting children talk to other children about their illness, such as alleviating fears and talking to others in similar situations. The benefits of discussions about illness have also been recognised by Peterson and Siegal (1999) who argue that children are better placed to make decisions regarding their care after conversations with parents or health professionals.

Finally, it has been shown that children have an understanding of what health is and they see it as more than just an absence of illness (Study 1). In fact, they prefer to define health in behavioural terms suggesting that they have a degree of understanding that their health is partly within their control. From the perspective of health education and practice, this knowledge could be emphasised and built upon. Furthermore, it is clear that children have knowledge of a variety of ways to avoid illness. Study 1 included questions on how to avoid getting the different illnesses/injuries and children gave responses including a variety of strategies. Importantly, they mentioned staying away from people who are ill. Thoughts such as this must be dealt with care as this may lead to prejudice against the sick and/or unnecessary anxiety. This is especially relevant in cases such as HIV transmission as children hold misconceptions about how this disease can be caught (Sigelman et al., 1993). However, sensitive and appropriate intervention can combat such dangerous misconceptions.

7.6. Directions for Future Research

This thesis has revealed some important findings relating to what methods are important in helping children understand about illness. However, it has also left some questions unanswered and opened up directions for future research. Some methodological changes that could be utilised in future research have already been discussed. This section will now cover directions for future research which will help advance our understanding of the issues surrounding the development of illness concepts. Specific points from the three studies will be discussed.

To expand on Study 1 and provide more information on children's baseline knowledge, it would be most relevant to extend the age ranges further and look at adolescent's understanding of illness. There is little work on this group's understanding of biology despite it being clear that children do not have a complete understanding in primary school. Specific to this thesis, the intervention studies have shown that 11 year olds still have room for their understanding to improve and that it can improve given the correct input. Furthermore, an important issue concerns the experiences which influence the development of children's understanding of illness. Children already have some form of knowledge of illness before formal schooling and identifying where this knowledge comes from is vital for knowing the best ways to approach teaching about illness. It has been suggested that information from sources such as parents and doctors have a profound effect on children's knowledge of illness and further work could look to utilise this in determining the best way to inform children about illness.

One area for expansion around Study 2 is further investigation into collaborative learning. The finding that factual information was more influential as an intervention than collaborative learning was not as expected and a priority area for future research would be to identify why this is so. Possible factors that could be investigated would be the composition of groups and the size of the groups. For example, children could be placed into groups where the different members hold differing conceptions of illness in the hope this induces socio-cognitive conflict (Piaget, 1926). Alternatively, whole class discussion as utilised by Hatano and Inagaki (1997) may be useful in that a greater variety of perspectives are consulted.

However of more interest is the impact of factual information, as shown by the results of both Study 2 and 3. Providing explanations was found to be a successful method of teaching children about illness and future research could look to investigate this further. In particular, it was a surprising finding that it was the content of the explanations, rather than the format in which it was presented that was the driving factor behind the improvements. More research is needed to identify the optimal level of explanations that children require at various ages and adapting the content of the factual information to teach about other biology concepts.

A crucial unanswered question from both intervention studies regards the underlying process of development that drives the observed changes in knowledge. It would be important to investigate this further as it has implication for how domain-specific theories of development can be used to inform educational practice. If the processes were identified, this could lead to the development of more effective intervention methods in the future as well as adding to theory on development.

7.7. Final Summary

Before this research, the literature on children's illness concepts was disparate and not very well integrated. It was usually the case that the different research history/background of the experimenter(s) led the research rather than the research question itself. Therefore, research of this nature was frequently qualified by the theoretical perspective, i.e. researchers investigating children's understanding of illness were influenced by their preconceived, sometimes prejudicial, ideas of where children's understanding of illness fitted into their priorities. This thesis has attempted to synthesise and integrate the different approaches towards understanding of illness in order to provide a more comprehensive picture of illness concepts. As a result, Study 1 has provided a clearer picture of children's understanding of a wider range of illnesses and illness processes than previous research. Valuable information on what these concepts are, when they emerge and the further development of these illness concepts has been gained. The results of this work were then translated into intervention studies, giving what had been discovered about children's knowledge of illness a practical application. A thorough investigation of intervention types was undertaken. This had not previously been researched with illness concepts, despite their practical importance. From the findings, we can see that children's understanding of illness can be enhanced through timely and age-appropriate intervention involving peer discussion and factual information. The results of the intervention studies have not only been useful in their practical implications but have also contributed to naïve biology and educational literature.

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Appendix I:

Interview schedule for Study 1/2/3

Today we are going to talk about some illnesses. I am going to ask you some questions about illness. Don't worry if you don't know the answer to something or if you are not sure about an answer. There are no right or wrong answers, I only want to know what you think.

Can you tell me what it means to be ill?

Can you tell me what it means to be healthy?

Cold

This is Johnny. Johnny has a runny nose and a sore throat. He is also coughing and sneezing a lot. This is because Johnny has a cold

Can you tell me what a cold is like?

How do you think Johnny got a cold?/Why would that make him get a cold?

What could Johnny have done to stop himself getting a cold?/Why would that have stopped him from getting a cold? (only asked in Study 1)

How long after getting a cold would Johnny start to feel bad?/ Why would it take that long?

Could Johnny do anything to make himself feel better?/ Why would that make him feel better?

How long do you think it would take for Johnny to feel better?/ Why would it take that long?

Chicken pox

This is Sally. Sally has lots of spots all over her face and body. She also has a sore head and is very tired. This is because Sally has chicken pox.

Can you tell me what chicken pox is like?

How do you think Sally got chicken pox?/ Why would that make her get chicken pox?

What could Sally have done to stop herself getting chicken pox?/ Why would that stop her getting chicken pox? (only asked in Study 1)

How long after getting chicken pox would Sally start to feel bad?/ Why would it take that long?

Could Sally do anything to make herself feel better?/ Why would that make her feel better?

How long would it take for Sally to feel better?/ Why would it take that long?

Asthma

This is Harry. Harry sometimes finds it difficult to breath.

He also coughs a lot. This is because Harry has asthma.

Can you tell me what asthma is like?

How do you think Harry got asthma?/ Why would that make him get asthma?

What could Harry have done to stop himself getting asthma?/ Why would that stop him from getting asthma? (only asked in Study 1)

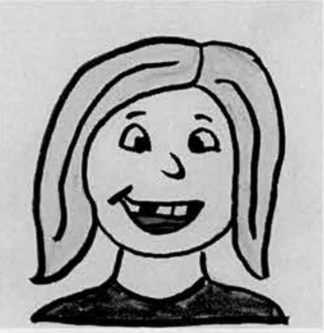
How long after getting asthma would Harry start to feel bad?/ Why would it take that long?

Could Harry do anything to make himself feel better?/ Why would that make him feel better?

How long would it take for Harry to feel better?/ Why would it take that long?

Toothache

This is Amy. Amy has a very sore tooth. She also has a hole in her tooth. This is because Amy has toothache.



Can you tell me what toothache is like?

How do you think Amy got toothache?/ Why would that make her get toothache?

What could Amy have done to stop herself getting toothache?/ Why would that stop Amy from getting toothache? (only asked in Study 1)

How long after getting toothache would Amy start to feel bad?/ Why would it take that long?

Could Amy do anything to make herself feel better?/ Why would that make her feel better?

How long would it take for Amy to feel better?/ Why would it take that long?

Broken leg (only asked in Study 1)

This is Ben. Ben has a very sore leg. He also has to have a plaster on it. This is because he has a broken leg.

Can you tell me what a broken leg is like?

How do you think Ben got a broken leg?/ Why would that make him get a broken leg?

What could Ben have done to stop himself getting a broken leg?/ Why would that stop him from getting a broken leg?

How long after getting a broken leg would Ben start to feel bad?/ Why would it take that long?

Could Ben do anything to make himself feel better?/ Why would that make him feel better?

How long would it take for Ben to feel better?/ Why would it take that long?

Bruise

This is Jenny. Jenny has a purplish patch on her knee. It is also a bit swollen. This is because Jenny has a bruise.

Can you tell me what a bruise is like?

How do you think Jenny got a bruise?/ Why would that make Jenny get a bruise?

What could Jenny have done to stop herself getting a bruise?/ Why would that stop Jenny from getting a bruise?

How long after getting a bruise would Jenny start to feel bad?/ Why would it take that long?

Could Jenny do anything to make herself feel better?/ Why would that make her feel better?

How long would it take for Jenny to feel better?/ Why would it take that long?

Tonsillitis (only asked in Study 3)

This is Harry. He has a very sore throat and a cough. He also has funny sounding voice and a high temperature. This is because he has tonsillitis.

Can you tell me what tonsillitis is like?

How do you think Harry got tonsillitis?/ Why would that make him get tonsillitis?

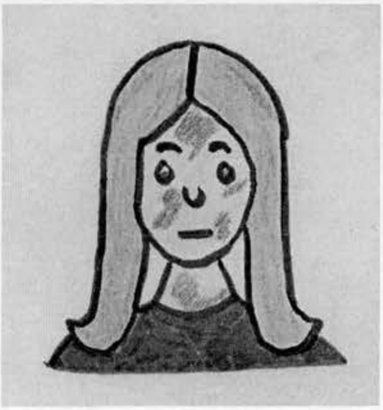
How long after getting tonsillitis would Harry start to feel bad?/ Why would it take that long?

Could Harry do anything to make himself feel better?/ Why would that make him feel better?

How long would it take for Harry to feel better?/ Why would it take that long?

Mosilitis (only asked in Study 3)

This is Amy. She has yellow skin and a rash on her face. She is also coughing and sneezing a lot. This is because she has mosilitis.



Can you tell me what mosilitis is like?

How do you think Amy got mosilitis?/ Why would that make her get mosilitis?

How long after getting mosilitis would Amy start to feel bad?/ Why would it take that long?

Could Amy do anything to make herself feel better?/ Why would that make her feel better?

How long would it take for Amy to feel better?/ Why would it take that long?

Appendix II:

Coding scheme for Study 1

1. Definition of illness (inter-judge reliability = 0.93)

Code	Category Label	Example
3	Symptoms / physical	Be sick
2	Behavioural	You have to stay off school
1	Psychological	Be sad
0	Don't know	

2. Definition of health (inter-judge reliability = 0.91)

Code	Category Label	Example
3	Absence of symptoms	You're fit and you're able to run and stuff
2	Behavioural	Means you eat a lot of healthy stuff like fruit and vegetables
1	Psychological	To be happy and to run around without having to worry
0	Don't know	

3. Definitions (inter-judge reliability = 0.97)

Code	Category Label	Example
2	Causality	Cold: If it was cold and you had been outside a lot
1	Symptoms	Chicken pox: Red spots and itchy
0	Don't know	

4. Causality (inter-judge reliability = 0.93)

Code	Category Label	Example
2	Biological	Cold: Someone else might have had it and they might have coughed germs onto him
1	Physical	Asthma: Swallowed lots of water from a bubble bath
0	Don't know	

5. Accuracy measure (inter-judge reliability = 0.86)

Code	Category Label	Example
4	Complete understanding of mechanism	Cold: he caught it off from someone else because he sneezed and the germs went inside him and made him ill
3	Partial understanding of mechanism	Chicken pox: caught them from somebody else cos she was playing too close them and the chicken pox might go onto them
2	Basic understanding	Toothache: eating sweets and sweets have

		sugar in them
1	Partial misunderstanding	Asthma: he was born with a problem with his heart
0	Complete misunderstanding / Don't know	Cold: from the cold weather

6. Prevention (inter-judge reliability = 0.90)

Code	**Category Label**	**Example**
2	Biological	Cold: Not gone near the person who had the cold so that their germs couldn't get inside you
1	Physical	Toothache: Don't eat sweets
0	Don't know	

7. Time course incubation (inter-judge reliability = 0.85)

Code	**Category Label**	**Example**
2	Complete understanding of time course	Broken leg: he would feel sore right away Cold: it would take a few days for him to be ill because the germs have to do their work
1	Some understanding of time course	Chicken pox: it would take a few days
0	No understanding of time course / Don't know	Cold: as soon as he came in from the cold

8. Recovery strategies (inter-judge reliability = 0.89)

Code	Category Label	Example
4	Seek medical help	Go to the doctors/hospital/dentist
3	Behavioural control	Broken leg: get crutches
2	Symptom relief	Asthma: Inhaler, then he would be able to run around as normal
1	Psychological	Bruise: Think like she didn't have a bruise
0	Don't know	

9. Time course recovery (inter-judge reliability = 0.90)

Code	Category Label	Example
2	Complete understanding of time course	Chicken pox: after a week she would feel better because that is how long it takes for the germs to go away
1	Some understanding of time course	Toothache: as soon as she went to the dentist
0	No understanding of time course / Don't know	Broken leg: it would feel better after a few days

Appendix III:

Fixed choice questions and responses for Study 2/3

How do you think that Jamie got a cold?

Because he went outside and played in the cold
Because he caught it off his friend Graham
Because he ate something that was bad for him

How long after getting a cold would Jamie start to feel ill?

Immediately
A few hours
A few days

What is the best thing that could Jamie do to make himself better?

Rest in bed
Go to the doctor
Take some medicine

How long would it take Jamie to feel better?

Immediately
A few hours
A few days

How do you think that Jenny got chicken pox

Because she went outside and played in the chicken pox

Because she caught it off her friend Amy

Because she didn't wash her face

How long after getting chicken pox would Jenny start to feel ill?

Immediately

A few hours

A few days

What is the best thing that Jenny could do to make herself better?

Rest in bed

Go to the doctor

Take some medicine

How long would it take for Jenny to feel better?

Immediately

A few hours

A few days

Appendix IV:

Intervention workbooks for Study 2 and 3

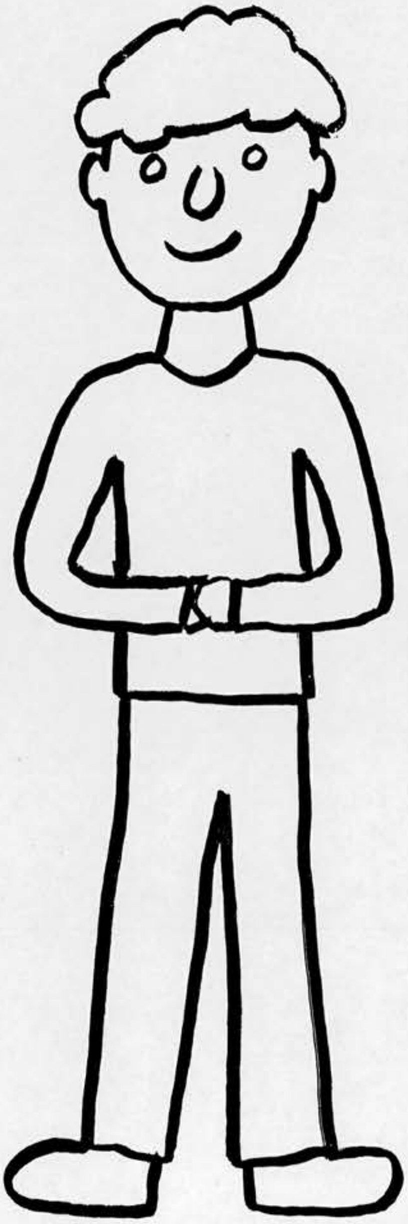
1. Full example of group + explanations workbook used in Study 2
2. Outline of individual tasks used in Study 2 and 3
3. Example of Scientific Facts information for colds used in Study 3
4. Example of No Explanation information for chicken pox used in Study 3

1. Full example of group+explanations workbook used in Study 2

Colds...

Please turn the page to begin.

This is a story about Jamie and how he got the cold. This is Jamie here.



One day Jamie went to see his friend Graham who was off school because he was ill. Graham had a cold.

*Find your card called **Answer Card 1 - Cold**.*

How do you think Jamie got a cold?

Take it in turns to tell each other what your answers are.

Do you all have the same answer?

*If **YES**: then fill in the blue card.*
Now discuss the reason why you think Jamie got a cold in that way and write it down in the space on the blue card.

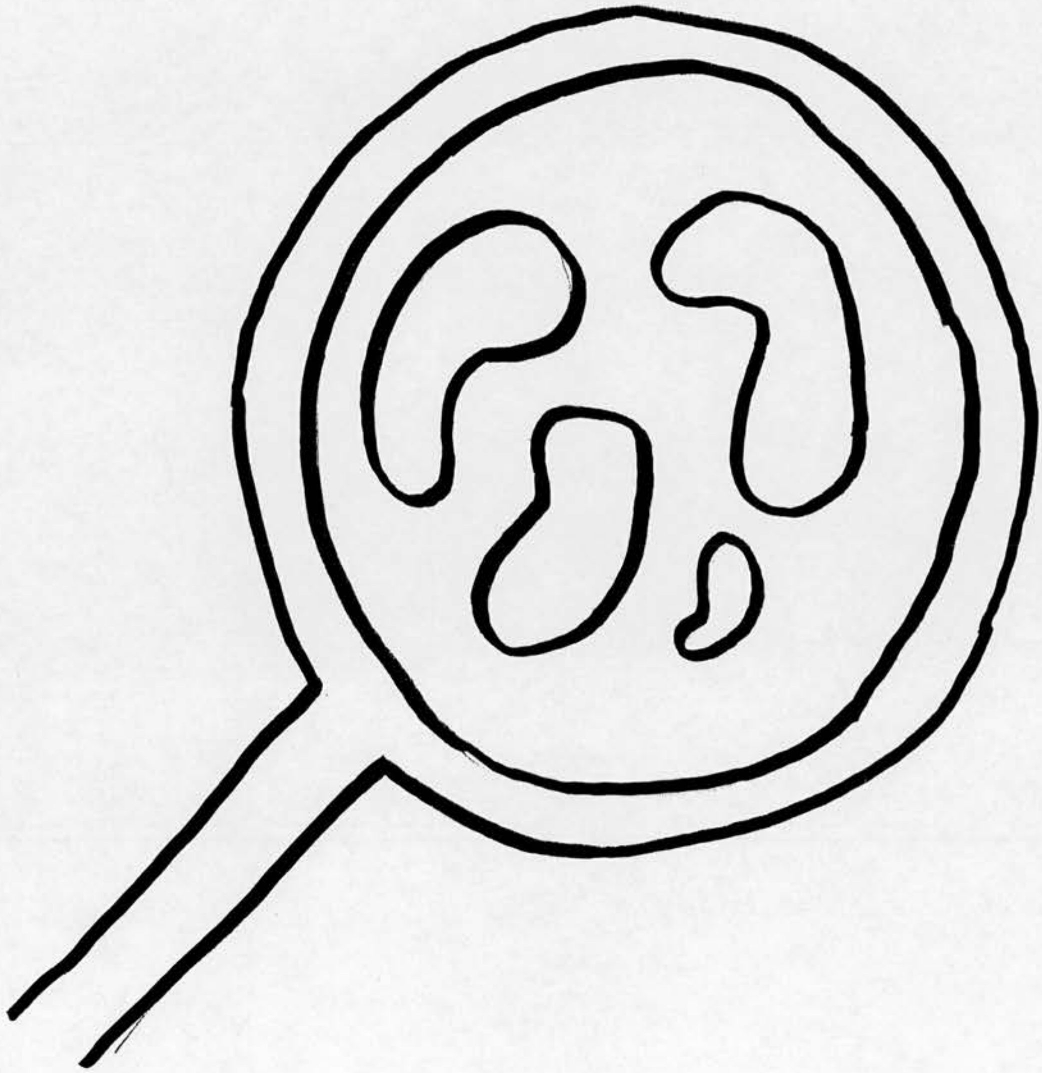
Now turn to the next page.

*If **NO**: then discuss your answers until you can agree on an answer.*

When you have agreed fill in the blue card.
Now discuss the reason why you think Jamie got a cold in that way and write it down in the space on the blue card.

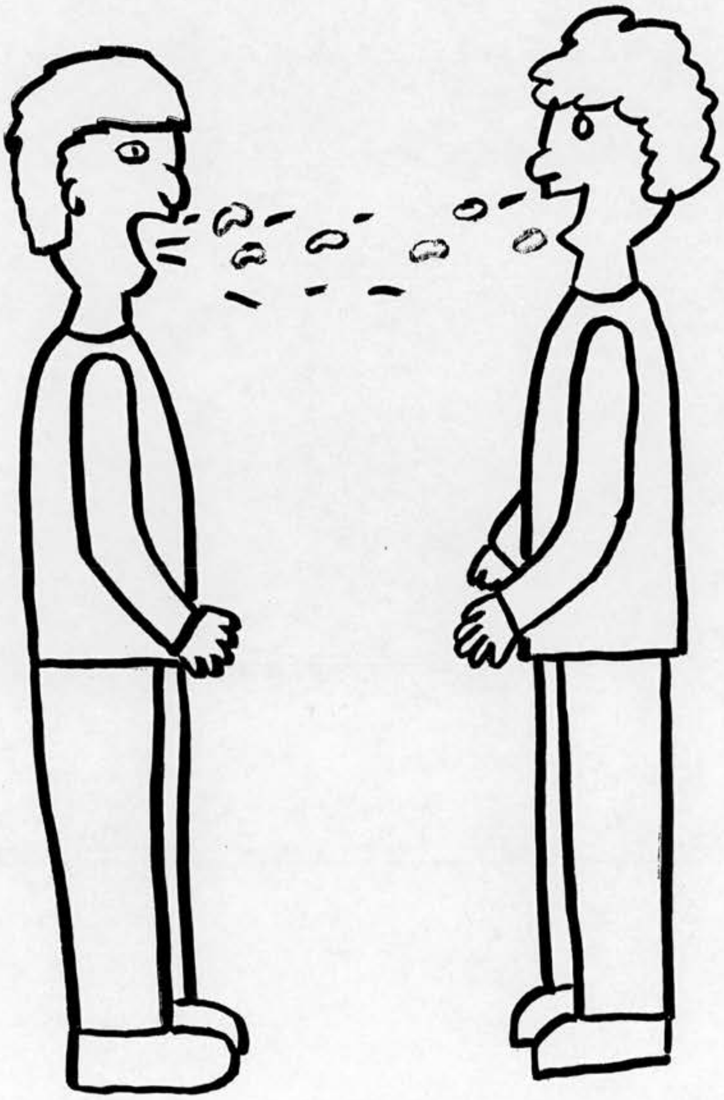
Now turn to the next page

Colds are caused by viruses which get inside your body and make you sick.



Viruses are a type of germ. They are tiny living things. In fact, viruses are so tiny that we need a microscope to see them. Viruses can get inside your body without you knowing and make you sick.

Jamie and Graham were playing in Graham's bedroom. Graham really didn't feel well though. He kept coughing and sneezing. What Graham and Jamie didn't know was that cold viruses were passing from Graham into Jamie.



When Graham was coughing and sneezing, droplets were flying through the air. These droplets had cold viruses in them. Jamie was breathing in these droplets without knowing it. The viruses were getting inside him and sticking to the inside of his nose.

Check your answer with the answer card in the envelope.

Did you have the right answer?

If **YES***: Did you have the right reasons for your answer? If you had the wrong reason for the answer then write the correct reason on the back of the blue card.*

Now turn to the next page.

If **NO***: Discuss why you got the question wrong. Write the correct answer and reason for the answer on the back of the blue card.*

Now turn to the next page.

*Find your card called **Answer Card 2 - Cold**.*

How long would it take for Jamie to start to feel ill?

Take it in turns to tell each other what your answers are.

Do you all have the same answer?

*If **YES**: then fill in the blue card.*
Now discuss the reason why you think it would take Jamie that long to start to feel ill and write it down in the space on the blue card.

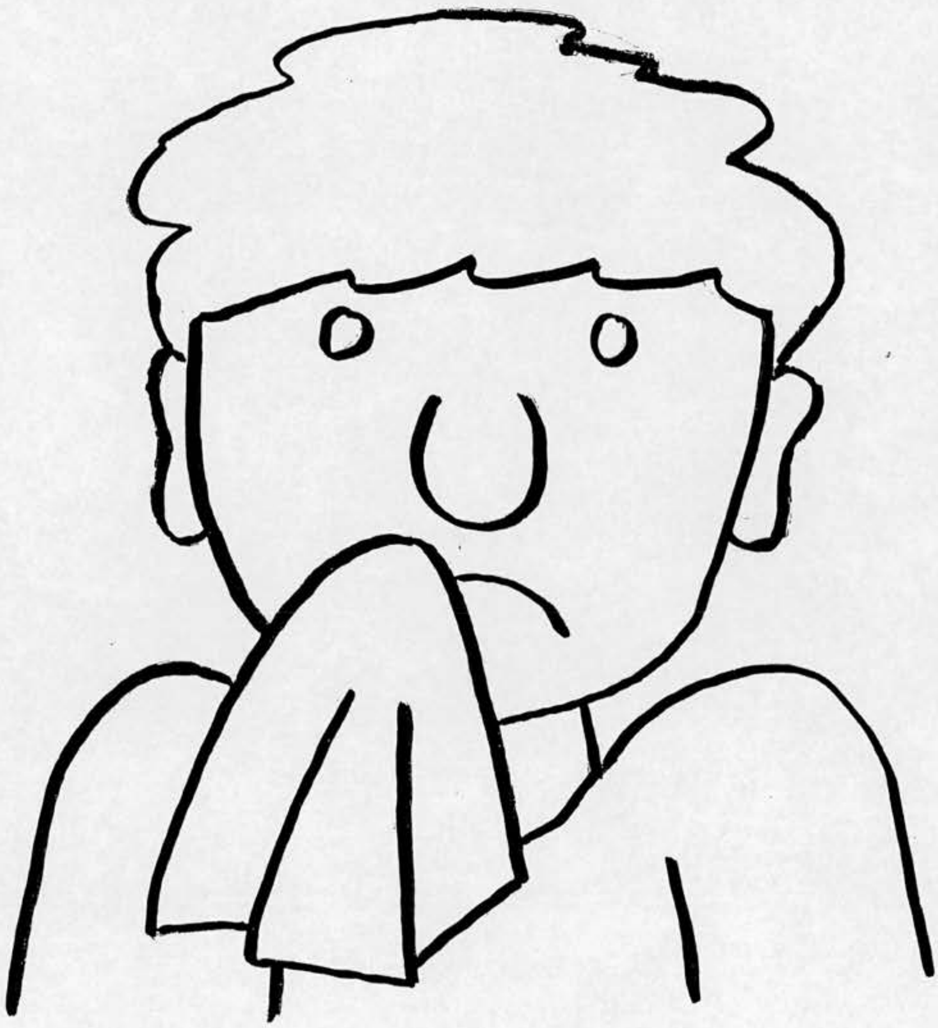
Now turn to the next page.

*If **NO**: then discuss your answers until you can agree on an answer.*

When you have agreed fill in the blue card.
Now discuss reason why you think it would take Jamie that long to start to feel ill and write it down in the space on the blue card.

Now turn to the next page

Jamie didn't know he had cold viruses inside him because he felt fine. In fact, it wasn't until two days later that he began to feel ill. This is because it takes time for the viruses to multiply and attack the body.



When the viruses get inside the nose, your body sends white blood cells to the rescue. That is why Jamie had a runny nose - it was trying to get the viruses out of his body. He also had a sore throat, a sore head and a cough.

Check your answer with the answer card in the envelope.

Did you have the right answer?

If **YES***: Did you have the right reasons for your answer? If you had the wrong reason then write the correct reason on the back of the blue card*

Now turn to the next page.

If **NO***: Discuss why you got the question wrong. Write the correct answer and reason for the answer on the back of the blue card.*

Now turn to the next page.

*Find your card called **Answer Card 3 - Cold.***

What is the best thing that Jamie could do to make himself feel better?

Take turns to tell each other what your answers are.

Do you all have the same answer?

If **YES***: then fill in the blue card.*
Now discuss the reason why you think that is the best thing that Jamie can do to make himself feel better and write it down in the space on the blue card.

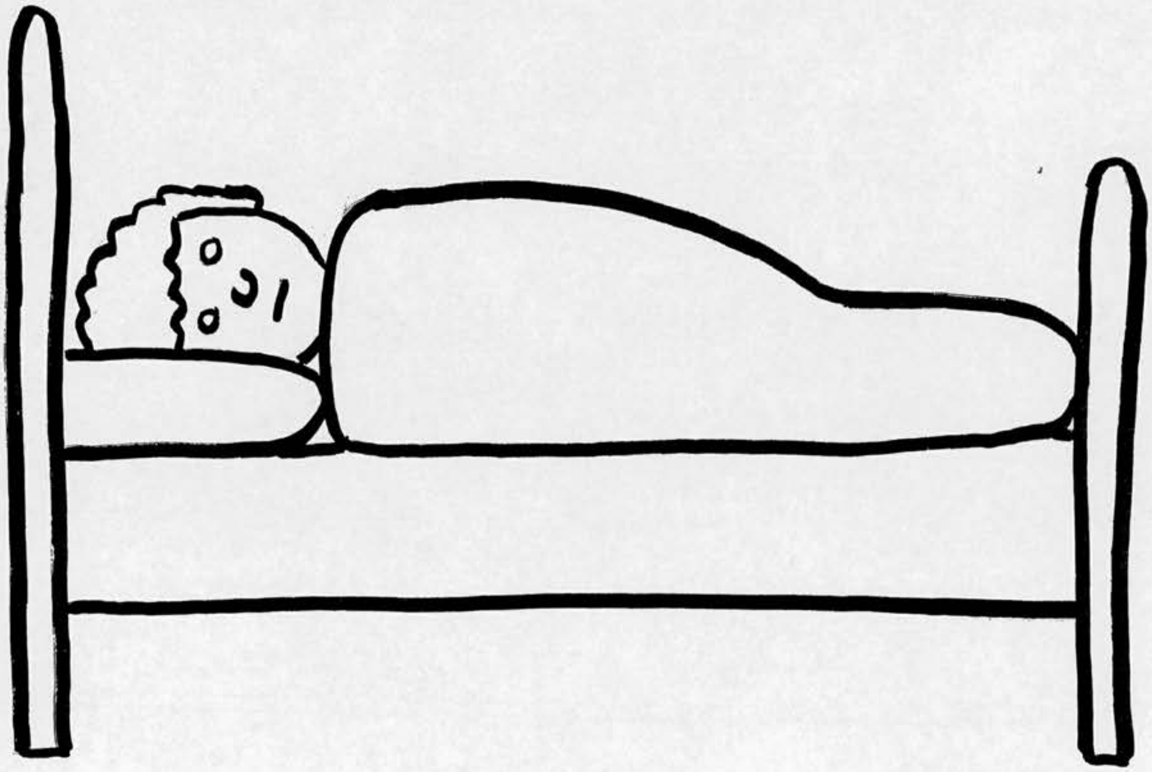
Now turn to the next page.

If **NO***: then discuss your answers until you can agree on an answer.*

When you have agreed fill in the blue card.
Now discuss the reason why you think that is the best thing that Jamie can do to make himself feel better and write it down in the space on the blue card.

Now turn to the next page

Jamie was quite miserable. He kept sneezing and felt very tired. His dad said that there was no medicine that can cure the cold. The best thing to do is let your body fight it.



Jamie had to rest and go to bed early, this made his body stronger to fight the viruses. To make himself feel better he took some cold medicines. This made him feel better but it didn't make the viruses go away

Check your answer with the answer card in the envelope.

Do you have the right answer?

If **YES:** *Did you have the right reasons for your answer? If you had the wrong reason then write the correct reason for the answer on the back of the blue card.*

Now turn to the next page.

If **NO**: *Discuss why you got the question wrong. Write the correct answer and reason for the answer on the back of the blue card.*

Now turn to the next page.

*Find your card called **Answer Card 4 - Cold**.*

How long would it take for Jamie to feel better?

Take it in turns to tell each other what your answers are.

Do you all have the same answer?

*If **YES**: then fill in the blue card.
Now discuss the reason why you think it would take Jamie that long to feel better and write it down in the space on the blue card.*

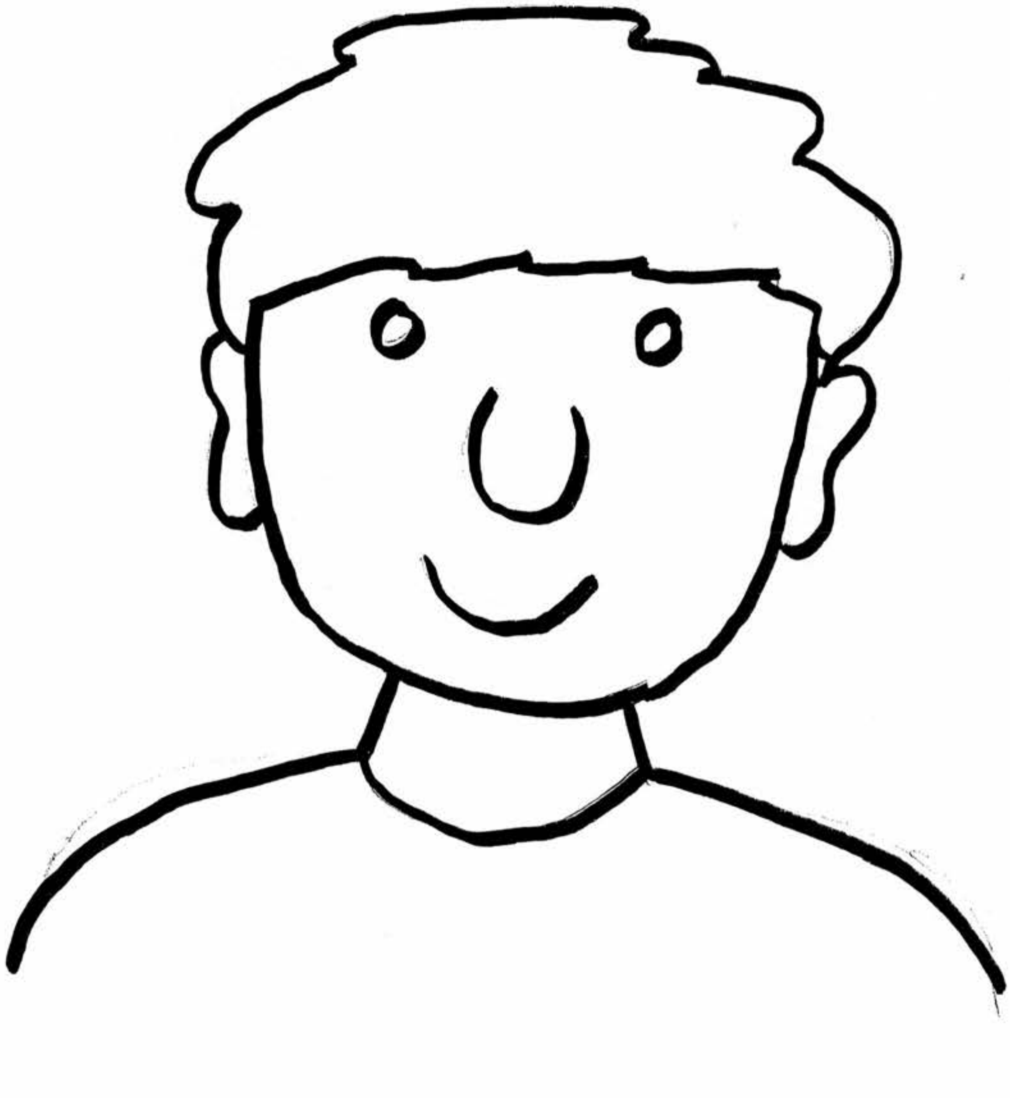
Now turn to the next page.

*If **NO**: then discuss your answers until you can agree on an answer.*

*When you have agreed fill in the blue card.
Now discuss the reason why you think it would take Jamie that long to feel better and write it down in the space on the blue card.*

Now turn to the next page

After about a week, Jamie began to feel much better. He was glad that it had only taken a week for his body to fight the viruses because he didn't like having a cold. He hoped he would never have a cold again.



He wanted to go out and play with his friends. His dad said be careful though: if he went near anyone who had the cold he might get it again!!

Check your answer with the answer card in the envelope.

Do you have the right answer?

If **YES***: Did you have the right reason for your answer? If you had the wrong reason then write the correct reason on the back of the blue card.*

If **NO***: Discuss why you got the question wrong. Write the correct answer and reason on the back of the blue card.*

You have now finished answering all the questions about Jamie's cold. Please tell the person who is helping you that you have finished.

2. Outline of individual tasks used in Study 2 and 3

- Find your card called **Answer Card 1 - Cold**.
- How do you think Jamie got a cold?
- Do you still think that?
- Think carefully of the reason why you think Jamie got a cold in that way and write it down in the space below.
- Now turn to the next page.

- Here is the right answer
- Did you have the right answer?
- If **YES**: Did you have the right reasons for your answer? If you had the wrong reason for the answer then write the correct reason on the back of your answer card.
- Now turn to the next page.
- If **NO**: Think carefully about why you got the question wrong and write the correct answer and reason for the answer on the back of your answer card.
- Now turn to the next page.

3. Example of Scientific Facts information for colds used in Study 3

This book will give you some information about colds.

The cold is an illness that lots of children have had.

Colds are caused by viruses which can get inside a person's body and make them sick

Viruses are a type of germ. They are tiny living things. In fact, viruses are so tiny that we need a microscope to see them. Viruses can get inside someone's body without them knowing and make them sick.

A person who has a cold can pass it to someone else by coughing or sneezing. This will make the cold viruses pass from one person to the other. When they cough, sneeze or talk, tiny drops come out of their mouth.

These drops are full of the cold virus. If someone breathes in the drops, the viruses will get in their body. They won't know that they have the cold viruses inside them.

It takes a few days after getting the viruses inside someone's body before they start feeling ill. This is because it takes time for the viruses to multiply and attack the body.

When the viruses get inside the nose, the body tries to defend itself by sending white blood cells to the rescue. That is why people get a runny nose - it is trying to get the viruses out of their body. They may also have a sore throat, a sore head and a cough.

The cold can make people feel very miserable. They keep sneezing and feel very tired. There is no medicine that can cure the cold. The best thing to do is to stay in bed. This lets the body get strong and fight the cold viruses.

To help make someone with the cold feel better, they can take some cold medicines. This will make them feel better, but it won't make the viruses go away.

After about a week the person will feel much better. They should feel well enough to do normal things and because they aren't coughing and sneezing anymore, they won't give the cold to any of the other children.

Be careful though: if you go near anyone who has the cold, you might get it again!!

4. Example of No Explanation information for chicken pox used in Study 3

This is a story about Jenny and how she got chicken pox. This is Jenny here.

One day Jenny went to see her friend Amy who was off school because she was ill. Amy had the chicken pox.

Chicken pox is caused by viruses which get inside your body and make you sick.

Viruses are a type of germ. They are tiny living things. In fact, viruses are so tiny that we need a microscope to see them. Viruses can get inside your body without you knowing and make you sick.

Jenny and Amy were talking in Amy's bedroom. Amy really didn't feel well though. She had a lot of spots and was coughing and sneezing.

Amy's face was covered in spots. Jenny thought this was very funny. What the girls didn't know was that Jenny was getting the chicken pox too.

Jenny didn't know she had chicken pox because she felt fine. She was still going to school and going out to play. In fact, it wasn't until TEN days later that she began to feel ill.

First she got spots all over her face. These spots were very itchy and Jenny wanted to scratch her face. As well as having spots, Jenny also had a sore head and felt sick.

Jenny was quite miserable. Her spots were very itchy and she was also very tired. Jenny wanted to get better quickly so she asked her mum what she could do. Her mum said that it was very important that she stayed in bed.

Jenny wasn't allowed to scratch her spots because that would make them burst and Jenny could be left with a scar. To stop her spots itching so much, Jenny's mum put some cream on them. This made the spots stop itching but it didn't make the chicken pox go away.

After six days the spots began to go away and Jenny felt much better. Jenny was very happy that she felt better because she didn't like the chicken pox. She hoped that she would never get chicken pox again.

Here is the best news: once you've had chicken pox, you probably will never get it again!!

Appendix V:

Coding scheme for Study 2 and 3

1. Definitions (inter-judge reliability = 0.83)

Code	Category Label	Example
5	Cause + symptoms + treatment	Asthma: If you do a lot of running and you can't breath properly so you need to get an inhaler
4	Symptoms + treatment or cause	Chicken pox: Wherever there is a chicken pox it's really itchy and you have to buy creams that stop the itching Toothache: It's just when your teeth is all sore cos you eat too many sweets
3	Accurate symptoms or cause or treatment	Cold: When you sneeze a lot and you've got a choked up throat and you just want to sneeze Tonsillitis: You have a very sore throat, hurts when you cough
2	Inaccurate or vague symptoms	Tonsillitis: When your tonsils go wrong Asthma: it's really itchy spots
1	Vague statement	Not nice/ annoying Chicken pox: Me and my friend Helen were watching tv and we got chicken pox on our bums Toothache: I've never really had toothache but this one really annoys me cos it's wobbly and that one there hasn't come in and it's been 7 months
0	Don't know	

2. Causality 0.89

Code	Category Label	Example
4	Full understanding of biological mechanism	Cold: Maybe someone else in his class had a cold and passed it onto him [how] cos a cold is like a wee germs thing that goes from person to person Cold: Could have caught it off somebody [how] if you are talking to someone who has a cold, they are breathing out germs and you are breathing them in
3	Understanding that something passes between people (contagion or inheritance)	Chicken pox: From friends [how] when they breath it out, you can breath it in and catch it Asthma: When he was a baby and maybe his mum or dad had it and they passed it on to him
2	Basic understanding it comes from someone else but no biological mechanism mentioned	Cold: Maybe someone else had them and she could have went near them too much and she could have catched them off her Mosilitis: She catched it from a friend Asthma: He was born with it
1	Physical/ external	Cold: He was out in the cold Chicken pox: Itching and stuff like that [how] just because getting infections in her face cos of like dirty nails
0	Don't know	

3. Time course incubation 0.85

Code	Category label	Example
4	Full understanding of incubation + reasonable explanation	Cold: Week [why] so that the germs could get into his body Cold: Day [why] cos the viruses have to multiply
3	Some understanding of incubation + attempted explanation	Chicken pox: Week [why] cos its hard to get all the chicken pox on your face and it would take a wee while to catch it Chicken pox: 2 days, the first day you get them appearing, and the next day they are itchy and the next day you feel ill
2	Some understanding of incubation + no explanation	Mosilitis: It would take a few days Asthma: When he was born
1	No understanding of incubation	Cold: Straight after he'd got it, it might go into his body and make him worse
0	Don't know	

4. Recovery 0.88

Code	Category label	Example
4	Accurate treatment based on internal processes	Tonsillitis: stay in bed to make the body strong so's the white blood cells can fight the germs
3	More than one accurate treatment	Cold: Keep blowing his nose and keep his clothes on Tonsillitis: Take some cough medicine, stay in bed and go to the doctors
2	Accurate treatment based on external actions	Chicken pox: Stay in bed for a while
1	Inaccurate treatment/ Behavioural response	Cold: Stay at home Asthma: He would have to cough it out and drink lots of water to make it come out
0	Don't know	

5. Time course recovery 0.84

Code	Category label	Example
4	Full understanding of recovery + reasonable explanation	Cold: Five or six days [why] cos the germs will eventually die down if you do the right things but they don't die down straight away, it takes a while for his body to beat the germs Cold: Three days [why?] cos your body has to fight the viruses
3	Some understanding of recovery + attempted explanation	Chicken pox: Days [why] if she got medicine she would have to wait until medicine started to work in her body
2	Some understanding of recovery + no explanation	Chicken pox: Few weeks
1	No understanding of recovery	Mosilitis: It would get better as soon as she took the medicine Toothache: Straight away
0	Don't know	

Appendix VI:

Published article from Study 1

This paper is included in this thesis with the permission of Sage publishers.

Children's Concepts of Health and Illness: Understanding of Contagious Illnesses, Non-Contagious Illnesses and Injuries

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Abstract

This study was designed to provide a more comprehensive picture of children's understanding of illness and injury than previous studies by interviewing 83 children from 4 age groups (4/5 years, 7/8 years, 9/10 years and 11/12 years). They were asked questions about how they defined illness and health as well as questions regarding different features of specific illnesses. First, it was found that definitions of health and illness became more polarized with age. Further, significant effects of age were detected for understanding of the specific illnesses with explanations becoming more sophisticated and accurate with development. This result held for almost every illness and illness feature. Lastly, cross-illness analyses showed that children hold differing levels of understanding for each ailment, e.g. understanding of injuries was higher than illnesses. These results contribute to health psychology literature on children's understanding of specific illnesses.

COMPETING INTERESTS: None declared.

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Keywords

children, concepts of illness, development

KNOWING HOW MUCH children understand about illness has both practical and theoretical implications. From a practical perspective, research on children's understanding of illness can be used to generate age-appropriate explanations for children affected by illness. This is especially pertinent in health care settings as children have frequently been shown to display unnecessary fear, guilt and anxiety before receiving treatment for illness (Whitt, Dykstra, & Taylor, 1979). Health education programmes used in schools could also benefit from being aware of children's baseline knowledge of health and illness. Furthermore, at a more general level, research on children's understanding of illness can inform theories regarding cognitive structures and cognitive development (Kalish, 1996a).

The question of how children define the concepts of health and illness is the starting point for this present study. Previous studies have focused on general definitions of health (Natapoff, 1978) or illness (Millstein, Adler, & Irwin, 1981) and only a few attempts have been made to compare definitions of the two (Millstein & Irwin, 1987; Schmidt & Frohling, 2000). Millstein and Irwin (1987) argue that concepts of health and illness become more polarized with age. While Schmidt and Frohling (2000) concluded that adequate definitions of health encompassed more than just an absence of illness. They found that describing negative aspects (e.g. absence of illness) decreased with age and describing positive aspects (e.g. positive mood) increased. In Schmidt and Frohling's study, illness was frequently described in terms relating to symptoms and a general feeling of being unwell; developmental changes were reflected in the number of aspects that were mentioned.

There has, however, been a substantial research effort exploring children's understanding of illness processes in detail. Historically, there have been two broad approaches to this. Early research attempted to plot the development of children's concepts of illness in line with the stages outlined in Piaget's theory of development (e.g. Bibace & Walsh, 1981; Perrin & Gerrity, 1981). Hence, it was argued that children's understanding of illness was limited. Bibace and Walsh (1981) conducted a series of clinical-style interviews based on children's understanding of the common cold and provided a detailed description of the development of children's illness concepts in terms of Piagetian stages. Causal explanations of illness given by children in the pre-operational stage (2 to 7 years) are described as based upon superstition or magic. There was a general conclusion in this early research that pre-operational children did not understand contagion or contamination as causes of illness. Kister and Patterson (1980) further report that 7-year-olds gave explanations of illness based on immanent justice and that younger children frequently over-extended contagion to non-contagious illnesses (toothache) and accidents. Bibace and Walsh argue that concrete-logical explanations are apparent in children aged 7 to 10 years when the children are thought to be able to distinguish between internal and external influences on the self. Explanations frequently cite contamination and internalization processes in the contraction of illness. The highest level of explanation is at the formal logical stage. By age 11 years children are described as able to give physiological explanations of illness that correspond to formal theories of infection, health maintenance and treatment.

Relatively recently it has been suggested that the neo-Piagetian approach underestimates children's understanding of illness. This corresponds with other criticisms of Piagetian research, which argue that his stage theory underestimates children's abilities such as reasoning about physical phenomenon (Baillargeon, 1993) and conservation of number (Donaldson, 1978). Furthermore, Hergenrather and Rabinowitz (1991) propose that it is incorrect to use Piaget's stages to plot the development of illness concepts as Piaget's stages refer to children's logic and capability for certain types of thought, not to their understanding. Carey (1985) also argues that illness cannot be conceptualized as part of a domain-general Piagetian framework as children's reasoning skills are very different across domains. By this account, domain-general theories may not be appropriate for explaining theoretical development within a specific domain. Despite these criticisms, Bibace and Walsh's stages have been used as the background for a lot of further studies on illness understanding (e.g. Banks, 1990; Crisp, Ungerer, & Goodnow, 1996; McQuaid, Howard, Kopel, Rosenblum, & Bibace, 2002) and have also sparked debate about the nature of the development of illness concepts.

The second approach to investigating children's understanding of illness corresponds with the recent growth of research concerning whether children have an intuitive understanding of biology (see Wellman & Gelman, 1992). Kalish (1996a) provides evidence for an early understanding of the biological processes of illness. In his study, pre-schoolers were asked to judge whether children who had contracted an illness in different ways would be ill and be contagious. The findings suggest that children see illness as more than just symptoms and whether or not someone was judged to be contagious depended on the cause. This indicates that contagion and infection may be linked by a theory of biology. In another set of studies Kalish (1996b) showed that pre-school children can understand that germs cause illness and that they are living things and therefore intrinsically biological agents. Further support for a biological conception of illness comes from Springer and Ruckel (1992) who showed that children preferred biological explanations of illness to social explanations.

However, Solomon and Cassimatis (1999) argue against a biological germ theory of illness. By asking pre-schoolers to judge whether someone would be contagious to others due to contact with a biological agent, e.g. germs, or a non-biological agent, e.g. pepper, they found that pre-schoolers did not distinguish between the types of agent in determining whether someone was contagious to others. Further studies indicated that pre-schoolers did not consider germs as living things. Solomon and Cassimatis stress that they are not against the idea that children have a grasp of some causal relations. They believe that children's understanding of illness undergoes a conceptual reorganization in order to become a biological theory although they do not suggest an age at which this may occur. Au and Romo (1999) argue further against a biological understanding of illness. Children aged 5–10 years were asked open-ended questions about how someone got sick and answers were coded according to how 'biological' they were. This led to a very small proportion of children (6%) being credited with a biological understanding of illness. Therefore, Au and Romo conclude that children do not possess the ability to reason biologically about phenomena and cannot talk about biological causal mechanisms. However, it can be noted that the coding scheme they use classifies many things as mechanical that other studies would say are biological and even the authors admit they may be being 'too harsh' (Au & Romo, 1999, p. 396).

However, this research is limited in that it focuses on pre-schoolers' understanding of contagion. As most of the work in this area has only considered pre-schoolers' understanding no real conclusions can be drawn about the development of illness concepts throughout the rest of childhood. This is especially relevant as the debate converges on whether pre-schoolers do have a biological understanding. If, as Solomon and Cassimatis argue, they do not then an area of further investigation would be to investigate when a biological understanding comes to the fore. Furthermore, the emphasis on understanding of germs and contagion has led to other illness processes and knowledge of specific illnesses being neglected (see also Williams & Binnie, 2002).

Research on adults' illness cognitions are potentially useful in providing a framework to extend research on children's understanding. In particular, the work of Leventhal and his colleagues (e.g. Leventhal, Meyer & Nerenz, 1980; Leventhal & Nerenz, 1985) highlights the functions and dimensions of adult illness representations. Illness representations function to help adults cope with their illness, understand their illness and help them to identify illness onset (Ogden, 1996). Leventhal and his colleagues distinguish between five elements of adult illness beliefs: identity (definition and symptoms) of illness; the causes of illness; the timeline; the consequences; and whether it is controllable and curable. This framework of illness dimensions broadens out the research possibilities for those working with children from a focus purely on causes and contagion to a consideration of a range of possible illness concepts.

The present study aimed to consider general definitions of the concepts of health and illness as well as understanding of specific illnesses. The age range in this study was extended to include children from 4 years up to 12 years allowing an examination of the development of illness concepts throughout primary school. It was predicted that concepts become more sophisticated and accurate with age. The specific illnesses are common childhood ailments that the children have some knowledge of as shown by previous research. In addition, more than just understanding of causality was investigated with questions on definitions, prevention, time course and recovery also being asked. It is likely that the children will have different levels of understanding of the different illnesses. An open-ended questioning method was used throughout to allow children to express their spontaneous thoughts. Although it was noted that the full extent of understanding among the youngest children may not be tapped by this type of method (Smith & Williams, 2004), it was hoped a more compete picture of understanding of illness will be obtained than by using forced choice methods. The study will be able to add to debate concerning intuitive biology as well as adding to health psychology literature on understanding of specific illnesses.

Method

Participants

A total of 83 children participated in this study from state-run primary schools and both state-run and private nurseries in Glasgow. The sample comprised four age groups: 4/5-year-olds (n = 20, Mean age = 4;7, range = 4;0–5;3); 7/8-year-olds (n = 20, M = 7;9, range = 7;4–8;2); 9/10-year-olds (n = 21, M = 9;9, range = 9;4–10;3) and 11/12-year-olds (n = 22, M = 11;9, range = 11;4–12;4). In total, there were 44 males and 39 females. The sample size was determined using power analysis. Assuming a large effect size and based on ANOVA comparisons of 4 groups, a minimum group size of 18 was recommended (Cohen, 1992).

The sample was selected through a process of Education Authority approval and school willingness to participate. Parents in the relevant age groups were then invited to give their permission for their children to participate in the study and were informed of the purpose of the study and the importance of the findings for health education and cognitive development research. They were also advised that all data would remain confidential and anonymous. Therefore, written parental permission was received for all participants. Due to a high level of asylum seekers in Glasgow, some participants (n = 5) did not have English as their first language and although they were interviewed in line with inclusive practice they were not included in this final analysis.

Pilot study

Initial items were extensively piloted on a sample of forty-five children. Nine common illnesses were asked about but this was reduced to six as the interview was felt to be too long. In addition, prompting was introduced as a result of the pilot study's findings as this yielded more insights into the children's knowledge. The final materials and procedure used are described below.

Materials

Introductory questions Two questions asking for general definitions of health and illness were drawn up (Can you tell me what it means to be ill/healthy?) as well as a question asking what illnesses the participant had personally experienced (Have you ever been ill? What illnesses have you had?). These questions served a dual function: first, it eased the participants into the interview situation and second, it allowed an examination of understanding of the concepts of health and illness in general.

Vignettes Six short vignettes were written describing child characters with different illnesses. The ailments described were: contagious illnesses (cold and chicken pox); non-contagious illnesses (asthma and toothache); and injuries (bruise and broken leg). Each vignette described the symptoms experienced by the character and gave the name of the illness. For example: 'This is Johnny. Johnny has a runny nose and a sore throat. He also coughs and sneezes a lot. This is because Johnny has a cold.' The vignettes were of the same form and complexity for each illness and described the same number of symptoms. In addition, to maintain the participant's interest, a cartoon drawing of each of the characters accompanied the vignettes. This method of employing vignettes, which facilitates children's ability to answer questions concerning their representations, has been used widely in research on illness (e.g.

Kalish, 1996, 1997; Siegal, 1988; Solomon & Cassimatis, 1999; Williams & Binnie, 2002) and children's understanding of biology more generally (e.g. Smith & Williams, 2004; Williams & Tolmie, 2000).

The questions about each illness, which followed the vignettes were:

Definition: What is [illness] like?

Causality: How do you think [name] got [illness]?/Why would that make [name] get [illness]?

Multiple causality: Can you think of any other ways that [name] could get [illness]?

Prevention: What could [name] do to stop himself/herself from getting [illness]?

Time course (1): How long would it take for [name] to feel bad?

Recovery: What could [name] do to make himself/herself feel better?

Time course (2): How long would it take for [name] to feel better?

Procedure

The participants were individually interviewed in a quiet room separate from their classroom. They were told they were going to be asked some questions about different illnesses, that there were no right or wrong answers and that they were free to leave the interview situation at any point. The introductory questions were asked first followed by the vignettes and questions for the specific illnesses. First the vignette was read out to the participant and they were shown the cartoon drawing. The questions about each illness were then asked. These always followed the same order. However, the order in which each of the illnesses was presented was randomized for each participant. The interviews were tape recorded and transcribed before analysis.

Content analysis

The data were coded using content analysis (see Krippendorff, 1980; Weber, 1995), a method frequently employed for analysing children's explanations of illness (Perrin, Sayer, & Willett, 1991; Raman & Winer, 2002; Sigelman, Maddock, Epstein, & Carpenter; 1993). Two coders used 15 per cent of the response scripts to devise appropriate categories. After discussion the final categories were decided and used to analyse the remaining response scripts by the two coders. The final categories were fairly broad in order to encompass responses to each of the illnesses/injuries. Although this may lead to missing some detail of the data that would remain with narrow categories it does have the advantage of allowing analysis of cross-illness comparisons. Since one of the purposes of this study was to look at cross-illness variations in representations it was crucial to devise a coding scheme that would allow statistical comparisons across the illnesses. Full details of the coding system are given in the Appendix. For the definitions of illness and health and the strategies for recovery, it can be seen that the data were coded into separate categories independent of each other. For definitions, causality and prevention a higher score indicated a higher level of response. An attempt was made to maintain a high level of detail with the coding of the causality questions by including an accuracy measure. This enabled responses to be coded in two ways: first, whether they were biological or physical and second, how accurately they described the mechanism. The time course items were also coded according to how accurate they were.

Results

The data for each question were analysed using either chi-square or two-way ANOVAs with follow-up tests. Where data were judged to be categorical and therefore non-parametric as in the case of definition of illness/health and strategies for recovery from illness, chi-square analyses were employed to explore age trends (in line with Charman & Chandiramani, 1995). However, some of the data were judged to be suitable for parametric testing as each response type superseded the other in level of sophistication and therefore a higher score indicated a greater level of understanding (Springer & Keil, 1991; Williams & Binnie, 2002; Williams & Tolmie, 2000). Thus, for questions on definition, causality, prevention and time course the data were analysed parametrically using Age Group (4/5 years, 7/8 years, 9/10 years, 11/12 years) × Illness Type (cold, chicken pox, asthma, toothache, bruise, broken leg) two-way

ANOVAs. Any main effects were then examined by use of post-hoc t-tests with corrections for the significance values and interaction effects were explored with the use of one-way ANOVAs and post-hoc Sheffes.

Definitions of illness

In relation to definitions of illness, Fig. 1 shows the percentage of children giving each response type. 'Don't know' answers decrease across the age groups and 'symptom' answers increase with age. Behavioural and psychological definitions are generally unpopular with all age groups. A chi-square test ($\chi^2 = 21.65, p < .01$) indicated the response pattern is associated with age.

Definitions of health

Figure 2 shows the percentages of participants invoking each response type for definitions of health. A different pattern to definitions of illness is seen. The most favoured category here is behavioural for the 7/8-year-olds and the 11/12-year-olds. The 4/5-year-olds prefer 'don't know' and the 9/10-year-olds mainly use definitions based on absence of symptoms. Chi-square test showed responses to be significantly associated with age ($\chi^2 = 45.37, p < .001$).

Definitions of the specific illnesses

A two-way ANOVA on the definition scores (Table 1) found a main effect of Age Group ($F(3, 79) = 7.70, p < .001$), a main effect of Illness Type ($F(5, 395) = 13.47, p < .001$) but no interaction effect. To explore the main effects of Age Group and Illness Type in detail, post-hoc t-tests were performed.

For Age Group it was found that the 4/5 years have a lower mean than 9/10 ($t(39) = -1.38, p < .001$) and 11/12 years ($t(40) = -4.27, p < .001$). Repeated measures t-tests comparing the different Illness Types across all ages showed that scores for asthma were lower than scores for cold ($t(82) = 4.88, p < .001$), chicken pox ($t(82) = 3.31, p < .001$), toothache ($t(82) = 4.17, p < .001$) and bruise ($t(82) = 6.71, p < .001$). Further, chicken pox scores were significantly lower than the injuries' scores: bruise ($t(82) = 5.05, p < .001$) and broken leg ($t(82) = 3.68, p < .001$).

Causality of specific illnesses

For understanding of the causality of illness (Table 2), a two-way ANOVA revealed a main effect of Age Group ($F(3, 79) = 14.26, p < .001$), a main effect of Illness Type ($F(5, 395) = 2.55$,

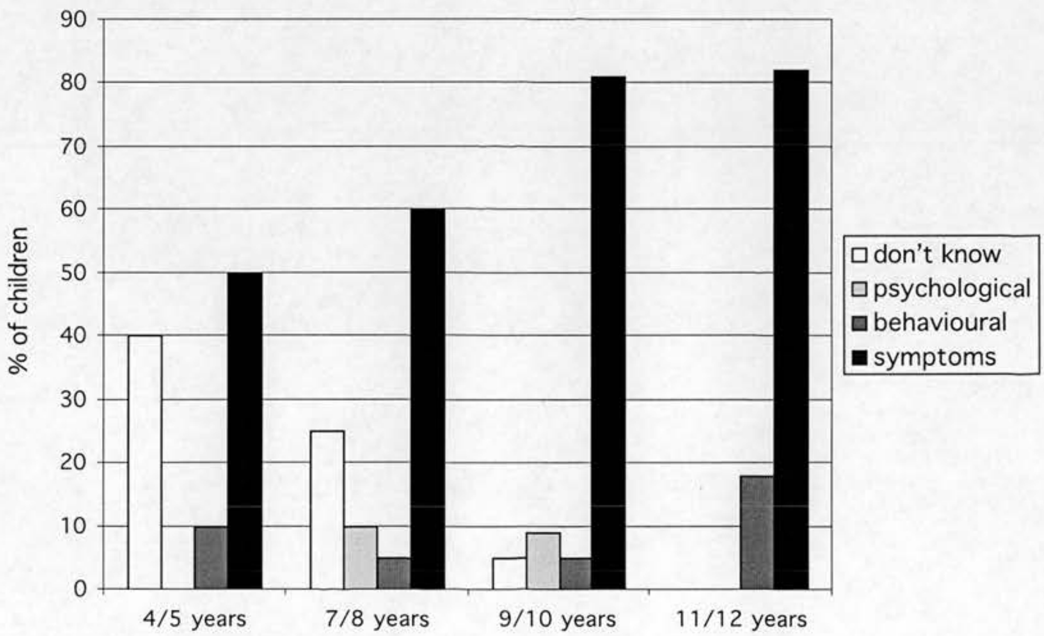

Figure 1. Percentage of children giving each type of definition for illness.

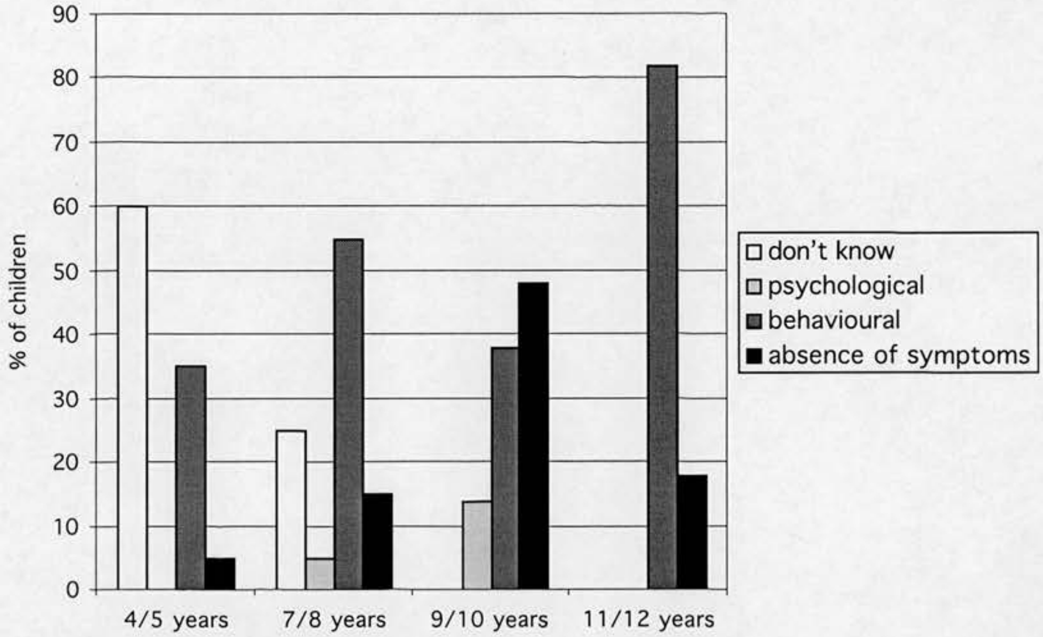

Figure 2. Percentage of children giving each type of definition for health.

$p < .001$) and an interaction effect ($F(15, 395) = 3.11, p < .001$).

Subsequent post-hoc t-tests showed 4/5 years have a lower mean than 9/10 years ($t(39) = -4.31, p < .001$), and 11/12 years ($t(40) = -6.31, p < .001$) and 7/8 years have a lower mean than 11/12 years ($t(40) = -4.00, p < .001$). Although a main effect of illness was found, the post-hoc t-tests did not show any significant differences between pairs of illnesses.

The interaction effect was initially explored using one-way ANOVAs with Scheffe post-hoc analysis (only significant differences are reported). There were significant developmental improvements between age groups for cold ($F(3, 79) = 4.59, p < .005$; 4/5 years have a lower

Table 1. Mean scores for definitions of illnesses by Age Group

	Cold	*Chicken pox*	*Asthma*	*Toothache*	*Bruise*	*Broken leg*
4/5 years	1.00	0.95	0.50	0.75	0.90	0.95
7/8 years	1.10	0.90	0.70	1.05	1.25	1.25
9/10 years	1.33	1.00	0.95	1.33	1.62	1.19
11/12 years	1.09	1.05	1.00	1.23	1.41	1.45

Table 2. Mean scores for causality of illnesses by Age Group

	Cold	*Chicken pox*	*Asthma*	*Toothache*	*Bruise*	*Broken leg*
4/5 years	0.65	0.40	0.55	0.90	0.95	0.85
7/8 years	1.00	0.80	0.60	0.95	1.00	1.00
9/10 years	1.19	1.33	0.85	1.00	1.00	1.00
11/12 years	1.00	1.55	1.18	1.50	1.00	0.95

mean than 9/10 years, $p < .01$), chicken pox ($F(3, 79) = 7.87, p < .001$; 4/5 years have a lower mean than 9/10 years and 11/12 years, $p < .01$ and 7/8 years have a lower mean than 11/12 years, $p < .05$ and toothache ($F(3, 79) = 8.07, p < .001$; 11/12 years have a higher mean than all other age groups, $p < .01$). There were no age differences for bruise, broken leg and asthma.

Accuracy measure for explanations of causality

Table 3 shows the accuracy of explanations for causality of illness. A two-way ANOVA indicated a significant main effect of Age Group ($F(3, 79) = 16.91, p < .001$), a significant main effect of Illness Type ($F(5,395) = 82.28, p < .001$) and a significant interaction effect between Age Group and Illness Type ($F(15, 395) = 3.174, p < .001$).

Further analyses detected differences in accuracy between 4/5 years and all other age groups: 7/8 years ($t(38) = 4.32, p < .001$), 9/10 years ($t(39) = 6.85, p < .001$) and 11/12 years ($t(40) = 7.24, p < .001$).

For the cross-illness post-hoc comparisons toothache, bruise and broken leg all have significantly higher means than cold, chicken pox and asthma (cold–toothache: $t(82) = -10.92, p < .001$; cold–bruise $t(82) = -16.27, p < .001$; cold–broken leg: $t(82) = -15.23, p < .001$; chicken pox–toothache: $t(82) = -5.53, p < .001$; chicken pox–bruise: $t(82) = -7.89, p < .001$; chicken pox–broken leg: $t(82) = -7.60, p < .001$; asthma–toothache: $t(82) = -10.07, p < .001$; asthma–bruise: $t(82) = -13.00, p < .001$; asthma–broken leg: $t(82) = -12.62, p < .001$) and chicken pox had greater score than cold ($t(82) = -4.87, p < .001$).

The interaction effect was examined by using one-way ANOVAs and post-hoc Sheffes comparing means for different age groups for each illness type separately. There were significant age differences in accuracy for chicken pox ($F(3, 79) = 7.87, p < .001$; 4/5 have lower mean than 9/10 and 11/12 years, $p < .005$) asthma ($F(3, 79) = 6.70, p < .001$; 4/5 have lower mean than 9/10 and 11/12 years, $p < .05$), toothache $F(3, 79) = 7.17, p < .001$; 11/12 have a higher mean than 4/5 and 7/8 years, $p < .01$), bruise ($F(3, 79) = 2.85, p < .05$; no pairwise differences detected) and broken leg ($F(3, 79) = 4.04, p < .01$; 4/5 have lower mean than 7/8 years, $p < .05$). No age differences were detected for cold.

Prevention of the specific illnesses

Table 4 shows clear developmental trends with prevention strategy scores increasing across the age groups for each illness. A two-way ANOVA found a main effect of Age Group ($F(3, 79) = 24.32, p < .001$), main effect of Illness Type ($F(5, 935) = 7.84, p < .001$) and a significant interaction effect ($F(15, 395) = 2.21, p < .01$).

Post-hoc t-tests looking for differences between the age groups found significant results between 4/5 years and all other age groups (7/8-year-olds: $t(38) = -4.103, p < .001$;

Table 3. Mean scores for accuracy measure by Age Group

	Cold	*Chicken pox*	*Asthma*	*Toothache*	*Bruise*	*Broken leg*
4/5 years	0	0.10	0	1.50	1.90	1.80
7/8 years	0.45	0.95	0.40	1.65	2.35	2.60
9/10 years	0.47	1.52	0.91	1.95	2.09	2.24
11/12 years	0.09	1.68	1.18	2.64	2.27	2.27

Table 4. Mean scores for prevention of illnesses by Age Group

	Cold	*Chicken pox*	*Asthma*	*Toothache*	*Bruise*	*Broken leg*
4/5 years	0.50	0.30	0.25	0.35	0.55	0.40
7/8 years	1.00	0.85	0.40	0.90	0.80	0.90
9/10 years	0.90	1.43	0.57	1.10	1.00	1.00
11/12 years	1.00	1.27	0.91	1.32	1.00	0.91

9/10-year-olds: $t(39) = -6.59$, $p < .001$; 11/12-year-olds: $t(40) = -7.13$, $p < .001$) and 7/8-year-olds and 11/12-year-olds ($t(40) = -3.19$, $p < .003$).

T-tests comparing the different Illness Types showed that asthma scores were significantly lower than for all other illnesses (cold: $t(82) = 3.99, p < .001$; chicken pox: $t(82) = 4.39, p < .001$; toothache: $t(82) = 4.71, p < .001$; bruise: $t(82) = 4.29, p < .001$; broken leg: $t(82) = 3.85, p < .001$).

The interaction effect was examined by comparing age differences within each illness using one-way ANOVAs with post-hoc Sheffe tests. There were significant age effects for all illness types: Cold ($F(3, 79) = 4.84, p < .005$; 4/5 have a lower mean than 7/8 and 11/12 years, $p < .05$); chicken pox ($F(3, 79) = 8.94, p < .001$; 4/5 have a lower mean than 9/10 and 11/12 years, $p < .001$); asthma ($F(3, 79) = 5.26, p < .005$; 11/12 have a higher mean than 4/5 and 7/8 years, $p < .05$); toothache ($F(3, 79) = 11.23, p < .001$; 4/5 years have a lower mean than all other age groups, $p < .05$); bruise ($F(3, 79) = 9.09, p < .001$; 4/5 have a lower mean than 9/10 and 11/12 years, $p < .001$) and broken leg ($F(3, 79) = 14.07$, $p < .001$; 4/5 years have a lower mean than all other age groups, $p < .001$).

Time course: accuracy in judging the incubation time of illness

Table 5 shows how accurate the participants in each age group were in their estimations of incubation time, i.e. the time between contracting the illness and 'feeling ill'. There was a main effect of Age Group ($F(3, 79) = 17.86, p < .001$), a main effect of Illness Type ($F(5, 395) = 8.35$, $p < .001$) and an interaction effect ($F(15, 395) = 2.29, p < .005$).

Post-hoc *t*-tests comparing age groups detect improvements in accuracy scores between the 4/5 years and all other age groups: 7/8 years: ($t(38) = -4.05, p < .001$); 9/10 years ($t(39) = -6.68$, $p < .001$) and 11/12 years ($t(40) = -7.56, p < .001$) and between 7/8 years and 9/10 years ($t(39) = -2.42$, $p < .05$) and 11/12 years ($t(40) = -2.70$, $p < .05$).

For the cross-illness main effect, post-hoc *t*-tests indicated asthma has a lower mean than bruise ($t(82) = -4.74, p < .001$) and broken leg ($t(82) = -4.92, p < .001$); and cold has a lower mean than bruise ($t(82) = -4.38, p < .001$) and broken leg ($t(82) = -0.38, p < .001$).

One-way ANOVAS with post-hoc Sheffes examining age trends within illness types were employed to investigate the interaction. Age differences were found for cold ($F(3, 79) = 3.80$, $p < .05$; 4/5 have a lower mean than 9/10 and 11/12 years, $p < .05$); chicken pox ($F(3, 79) = 5.40$, $p < .005$; 4/5 have a lower mean than 9/10 years, $p < .01$ and 7/8 have a lower mean than 9/10, $p < .05$); toothache ($F(3, 79) = 6.98, p < .001$; 4/5 have a lower mean than all other age groups, $p < .05$); bruise ($F(3, 79) = 8.60, p < .001$; 4/5 have a lower mean than all other age groups, $p < .01$) and broken leg ($F(3, 79) = 11.11, p < .001$; 4/5 have a lower mean than 9/10 and 11/12 years, $p < .005$ and 7/8 have a lower mean than 11/12 years, $p < .01$). There were no age trends for asthma.

Recovery

Figure 3 shows the percentage of children giving each recovery strategy for the six illnesses. In general the most favoured strategy is symptom relief. For toothache, most children referred to seeking medical help. As for all other illness features, asthma shows the highest number of don't know responses.

To explore this overall trend in more detail, associations between recovery strategies and age were examined for each illness type using chi-square. The results were significant in relation to cold ($\chi^2 = 29.85, p < .005$), bruise ($\chi^2 = 24.64$, $p < .05$) and broken leg ($\chi^2 = 27.83$, $p < .01$).

Table 5. Mean accuracy scores for predicting incubation time of illnesses by Age Group

	Cold	*Chicken pox*	*Asthma*	*Toothache*	*Bruise*	*Broken leg*
4/5 years	0.05	0.20	0.20	0.05	0.01	0.20
7/8 years	0.45	0.30	0.10	0.75	1.30	0.70
9/10 years	0.76	1.15	0.48	0.86	1.33	1.24
11/12 years	0.77	0.73	0.64	1.00	1.09	1.64

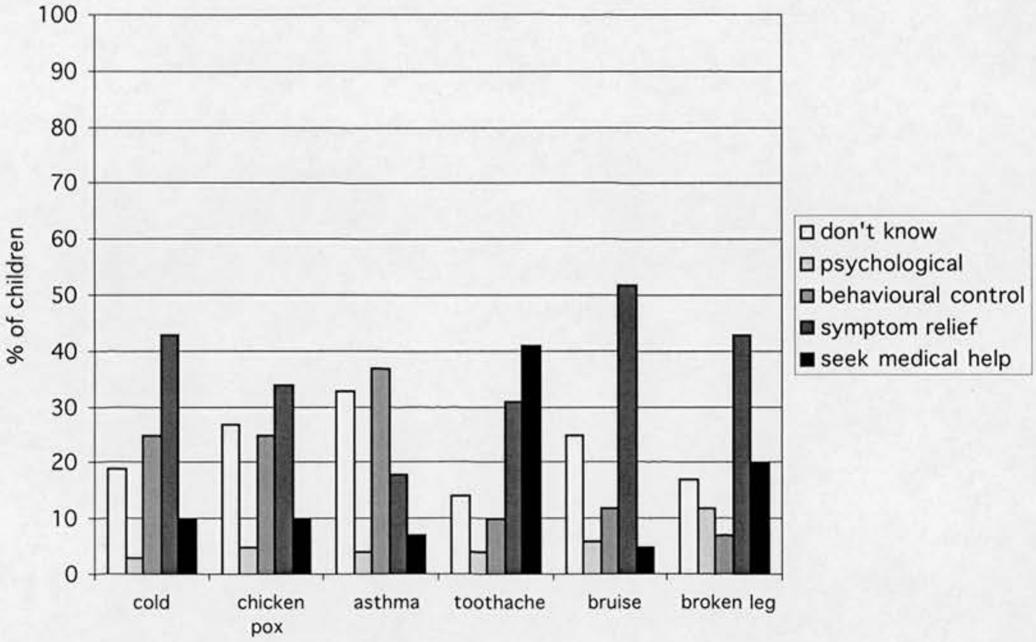

Figure 3. Percentage of children giving each recovery strategy for each illness.

Time course 2: accuracy of judgements of time to recovery

Table 6 shows the accuracy of answers regarding time to recovery. A two-way ANOVA found a main effect of Age Group ($F(3, 79) = 26.66$, $p < .001$), main effect of Illness Type ($F(5, 395) = 13.76, p < .001$) and an interaction effect ($F(15, 395) = 1.91, p < .05$).

Exploring the main effect of Age Group, post-hoc t-tests showed significant increases in accuracy between 4/5 years and all other age groups: 7/8 years ($t(38) = -3.55$, $p < .001$); 9/10 years ($t(39) = -8.74$, $p < .001$); 11/12 years ($t(40) = -8.23$, $p < .001$). Seven/eight years also have a lower mean than 9/10 ($t(39) = -3.61$, $p < .001$) and 11/12 years ($t(40) = -3.33, p < .005$).

For Illness Type, toothache has a lower mean than cold ($t(82) = 3.79$, $p < .001$), chicken pox ($t(82) = 5.95, p < .001$), bruise ($t(82) = -3.34, p < .001$) and broken leg ($t(82) = -6.45$, $p < .001$). Asthma has a lower mean than chicken pox ($t(82) = 4.88$, $p < .001$) and broken leg ($t(82) = -5.30, p < .001$).

In relation to the interaction there were significant age differences for all illness apart from asthma: cold ($F(3, 79) = 14.91, p < .001$; 4/5 have a lower mean than 9/10 and 11/12 years, $p < .001$ and 7/8 have a lower mean than 9/10 and 11/12 years, $p < .005$) chicken pox ($F(3, 79) = 12.73$, $p < .001$; 4/5 have a lower mean than 9/10 and 11/12 years, $p < .001$ and 7/8 has a lower mean than 9/10 years, $p < .05$) toothache (F(3,

Table 6. Mean accuracy scores for predicting time to recovery of illnesses by Age Group

	Cold	*Chicken pox*	*Asthma*	*Toothache*	*Bruise*	*Broken leg*
4/5 years	0.20	0.30	0.30	0.20	0.20	0.55
7/8 years	0.55	0.95	0.40	0.45	0.95	1.00
9/10 years	1.38	1.62	0.48	0.71	1.05	1.62
11/12 years	1.27	1.41	0.73	0.77	1.09	1.41

79) = 6.95, $p < .001$; 4/5 have a lower mean than 9/10 and 11/12 years, $p < .01$) bruise ($F(3, 79) = 8.57$, $p < .001$; 4/5 have a lower mean than all other age groups, $p < .01$) and broken leg ($F(3, 79) = 7.66$, $p < .001$; 4/5 have a lower mean than 9/10 and 11/12 years, $p < .01$).

Discussion

This study has shown the development of children's understanding of health and illness between the ages of 4 years to 12 years. As predicted, children's knowledge of illness becomes more sophisticated and accurate with age. This was found both for general definitions of health and illness and also for knowledge of specific illnesses. Furthermore, it was expected that children would hold differing levels of knowledge for the specific illnesses investigated and this was supported with knowledge of injuries being much greater than the illnesses with a particularly low understanding of asthma.

In this study, the most frequent definition of illness was based upon the presence of symptoms and feeling poorly. Even some of the 4/5-year-olds were able to define illness in this way, although the majority answered 'don't know'. In contrast, definitions of health were more commonly based on behavioural factors therefore indicating health is not necessarily defined as the opposite of illness. Millstein and Irwin (1987) suggest that health and illness are different but overlapping constructs. They looked at these concepts among adolescents and found that the degree of overlap varied with age with older adolescents seeing health as more than just absence of illness. The results of the present study extend this by looking earlier into childhood. The results show polarization of the concepts as the 9/10-year-olds gave definitions that appear to associate health with absence of illness but 11/12-year-olds move away from illness-related definition and gave more definitions based on health-related behaviours.

It is well documented that children's understanding of illness becomes more sophisticated with age (e.g. Bibace & Walsh, 1981; Charman & Chandiramani, 1995) and this study supports this further by including a wider range of illnesses and processes than previous studies. The most commonly found effect of age in this study was that 4/5 years had lower means than the older age groups (9/10 years and 11/12 years). In addition, 7/8 years also frequently showed differences from the 4/5 years, for example accuracy of judgements of time course. This indicates equivalent developmental progression across illnesses and across processes. Comparing across illnesses for each process has shown that children can have understanding of one ailment without understanding another to the same degree. For example, although accuracy of explanations of causality of toothache was quite high across all age groups, accuracy of explanations for asthma, another non-contagious illness, was significantly lower. This indicates the importance of considering the variation in understanding of specific illnesses when researching children's concepts.

In order to provide a complete overview of the findings and interpret them in respect to previous literatures in both developmental and health psychology, each illness will now be considered separately. The following paragraphs mainly discuss understanding of causality as this has been the focal point of previous literature and it is therefore easy to draw comparisons but the findings of the other processes are also considered.

Despite the cold being a common contagious ailment that children are likely to have extensive direct experience of, there was a large proportion of misconceptions made apparent in this study. Specifically, children at all ages were more likely to refer to cold weather than contagion to explain the causality of colds. Sigelman and Alfeld-Liro (1995) suggest this misconception may be prevalent due to the nature of colds. The symptoms of a cold can be described as cold-like e.g. runny noses and chills and children tend to get more colds in the winter than in the summer. More importantly, however, children are frequently told by their parents that they will catch a cold if they go out in the cold weather without proper protection. This indicates how powerful parental influence is in giving children advice related to health. Despite a naïve conception of causality of colds, the children in this study did show fairly sophisticated reasoning of the other aspects of colds such as definitions, prevention and recovery.

Knowledge of the causality of chicken pox was greater than for cold, which further suggests it is not a lack of understanding of contagion that underlies misconceptions of cold. This study shows that children are capable of conceptualizing the causality of chicken pox in biological terms even at age 4/5 years. However, explanations of the biological mechanisms involved in contagion do not become accurate until age 9/10 years. Knowledge relating to chicken pox specifically has only been investigated by a handful of studies (e.g. Charman & Chandiramani, 1995; Peltzer & Promtussananon, 2003) but knowledge of contagion has been extensively studied (e.g. Kalish, 1996a, 1996b; Solomon & Cassimatis, 1999). The finding of this study that children are capable of referring to a biological framework of understanding at age 4/5 years without having knowledge of the specific mechanisms at work would appear to bridge the gap between contradictory findings by these studies. It is possible that children have an idea that some illnesses are caught off other people (Kalish, 1996a, 1996b) without knowing the details (Au & Romo, 1999; Solomon & Cassimatis, 1999). In addition, the older age groups of children have the beginnings of an understanding of the incubation period involved in this contagious illness and the time to recovery. However, the younger children frequently answer that someone would get chicken pox immediately showing little understanding of the biological processes involved in the reproduction of viruses and this effect on the body.

Of all the illnesses investigated in this study, understanding of asthma was the lowest. Asthma is a non-contagious illness and there is extensive literature on children's understanding of asthma in terms of health care and practice (Eiser, Town & Tripp, 1988; Ireland, 1997; McQuaid et al., 2002). This study adds to this literature by considering a general sample of children and the development of their understanding of asthma in relation to other illnesses. In terms of biological understanding, causality of asthma is sometimes understood in terms of inheritance. Although it is not entirely clear what causes asthma, older children in this study considered there to be a genetic component. Physical causes of asthma reported by children included triggers for allergies and exercise, which were noted by all age groups except the 4/5 years. Understanding of the other features of asthma was low across all age groups. Recovery strategies specified by the older age groups included using inhalers and avoiding behaviours such as running which might trigger an attack.

Children in the 11/12-year-old age group were capable of giving quite sophisticated and accurate accounts of the decay processes involved in toothache and even children in the younger age groups were able to identify physical/behavioural factors that would contribute to toothache such as not brushing their teeth. This contradicts previous research that found that children overextended contagion as an explanation of toothache (Kister & Patterson, 1980) and expands on Siegal's (1988) finding, which argued children did not perceive toothache as a contagious illness but did not suggest how children understood the cause of toothache. Knowledge of prevention of toothache was high which reflects the efforts of community and school health programmes to educate children in the benefits of oral hygiene. The most frequently mentioned recovery strategy was going to the dentist and there was some understanding displayed as to the time course of toothache.

Children in all age groups showed comprehensive knowledge of both injuries: bruise and broken leg. Definitions were attempted by all age groups and a mix of symptoms and causality was mentioned. Causal explanations were all physical but more detailed and accurate explanations were given by the older children. Interestingly, some psychological strategies for recovery were mentioned here which were not found for the illnesses. Prevention strategies mainly focused on 'being careful' and there was some degree of awareness of the time course of injuries. This finding that knowledge of injuries is greater than of illness supports Williams and Binnie (2002) who suggest that this is due to greater experience with minor injuries as well as the more observable external effects of injuries.

Previously, research such as this has been used to inform practice in health care settings. For example, Rushforth (1999) describes how research into children's understanding of health and illness can inform care in hospital situations such as preparing children for medical procedures. However, there has been little attempt to relate this research to more general health education in schools. Accurate health education is important as illustrated by how predominant the misconception that colds are caused by cold weather is in children of all ages. In addition, the children in this study were capable of citing many variables that would keep them healthy but this did not indicate a deep understanding of processes involved in staying healthy. Further, it is not clear whether this knowledge of what makes you healthy leads to appropriate health-maintaining behaviours, which could be an area of future research (Bennett & Murphy, 1997; Conner & Norman, 1995; Pitts, 1996).

It is a prevalent finding in this study, that children understand more about illness than research from the 1980s would suggest. There are two possible reasons for this. First, early research did not use child-friendly methodologies. This present study used a child-sensitive open-ended questioning method that did not place unnecessary task demands on any of the age groups. It is acknowledged that due to limited verbal ability, the 4/5-year-olds may not have been capable of displaying their full understanding but they were still able to participate and offer answers for all of the interview items. Second, there is more awareness of health and illness in the public domain and a greater emphasis on health education in schools. This could be leading to increased interest and greater understanding of health-related issues in this generation of children compared to the early 1980s, which indicates the potential of successful health education.

In terms of future research, it would be useful to take a variety of approaches in exploring children's understanding of illness. These should include both quantitative research to replicate and extend the findings presented here and also qualitative work to provide an in-depth account of the variety of children's understandings around different illnesses. This study has successfully extended research on children's understanding of illness by including dimensions other than causation. However, an important remaining issue concerns the experiences that influence the development of children's understanding of illness. It has been suggested that both health education in schools and information from other sources such as parents and doctors have a profound effect on children's knowledge of illness and further work should look to utilize this in determining the best way to inform children about illness.

This study aimed to provide a more comprehensive picture of children's understanding of illness than previous research by investigating knowledge of specific contagious illnesses, non-contagious illnesses and injuries. It has been shown that children are capable of talking about illness as young as age 4/5 years and their explanations and understanding become more complex with maturity. This research has important implications for the timing and content of health education and for theories of cognitive development.

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Appendix. Coding system

Question (inter-judger reliability)	*Score*	*Category label*	*Example*
Definition of illness (0.93)	3	Symptoms/physical	'Be sick'
	2	Behavioural	'You have to stay off school'
	1	Psychological	'Be sad'
	0	Don't know	
Definition of health (0.91)	3	Absence of symptoms	'You're fit and you're able to run and stuff'
	2	Behavioural	'Means you eat a lot of healthy stuff like fruit and vegetables'
	1	Psychological	'To be happy and to run around without having to worry'
	0	Don't know	
Definition (0.97)	2	Causality	'If it was cold and you had been outside a lot'
	1	Symptoms	'Red spots and itchy'
	0	Don't know	
Causality (0.93)	2	Biological	'Someone else might have had it and they might have coughed germs onto Johnny'
	1	Physical	'Swallowed lots of water from a bubble bath'
	0	Don't know	
Accuracy measure (0.86)	4	Complete understanding of mechanism	
	3	Partial understanding of mechanism	
	2	Basic understanding	
	1	Partial misunderstanding	
	0	Complete misunderstanding/don't know	
Prevention (0.90)	2	Biological	'Not gone near the person who had the cold so that their germs couldn't get inside you'
	1	Physical	'Don't eat sweets'
	0	Don't know	
Time course [1](0.85) and [2] (0.90)	2	Complete understanding of time course	
	1	Some understanding of time course	
	0	No understanding of time course/don't know	
Recovery (0.89)	4	Seek medical help	'Go to the doctors/hospital/dentist'
	3	Behavioural control	'Get crutches'
	2	Symptom relief	'Inhaler, then he would be able to run around as normal'
	1	Psychological	'Think like she didn't have a bruise'
	0	Don't know	